

LAND USE AND BASIN CHARACTERISTICS INFLUENCING WATER
TEMPERATURE AND SUSPENDED SEDIMENT IN THE
MOHAWK RIVER BASIN, OREGON

by

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Title: LAND USE AND BASIN CHARACTERISTICS INFLUENCING WATER
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The intensity of land use or vegetative manipulation can deleteriously affect water quality. Water temperature and suspended sediment in the Mohawk Basin were analyzed to determine the impact land use has on water quality.

Maximum water temperatures were sampled in late summer, the season of low flow and high air temperature. Suspended sediment sampling took place during the winter. Influences of basin character, land use, and soil type, on water temperature and suspended sediment, were investigated using

linear regression analysis.

Land use was found to have a significant effect on water temperature. Increased temperatures are related to greater percentages of total area logged. Temperatures increased slightly as the percentage of agricultural land increased.

Suspended sediment and discharge correlate in fall, but not in winter. Decline of sediment availability, as the high flow season progresses, apparently is the limiting factor. No clear relationship was found between suspended sediment and land use.

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CHAPTER I

INTRODUCTION

The purpose of this study is to determine the influence of environmental conditions, particularly land use, on stream temperature and suspended sediment concentration in the Mohawk River Basin of western Oregon. The presence or absence of vegetation adjacent to rivers and streams directly affects the water temperature. Removal of streamside vegetation increases the surface area of water exposed to direct sunlight and the duration of exposure, both of which serve to elevate stream temperature. The quantity of suspended sediment present in the stream system depends on the extent of soil disturbance and vegetative manipulation to which the watershed has been subjected.

The Mohawk Basin was chosen for study for several reasons. First of all, the basin supports both forest and agricultural land use practices. Second, there is no industry currently operating in the basin discharging effluents into the water system which could confuse the findings. Third, the Bureau of Land Management (BLM), is currently monitoring the Shotgun Creek area, a sub-basin of the Mohawk, for suspended sediment. The data and results of

my study will provide the BLM with a basin-wide view of the suspended sediment activity and its relationship to land use. In addition, the temperature analysis will provide the BLM with a base line data set of water temperatures for the drainage area, and it will show the relationship between temperature, land use, and basin characteristics.

The Mohawk River Basin is located on the southeastern edge of the Willamette Valley in western Oregon (see Figure 1). The nearest city is Springfield immediately southwest of the basin. The drainage area of the basin is 458.4 km^2 (178.5 mi^2), and it is a sub-basin of the McKenzie River Basin.

Collection of stream temperature data began in August of 1986 and continued through September of 1986. This time period was selected in order to determine the maximum water temperatures attained during seasonal low flow and high ambient air temperatures. Water sample collection for suspended sediment began in October of 1986 and continued through the rainy season until March of 1987. Linear regression models were developed to relate both water temperature to land use and basin characteristics, and suspended sediment to land use and basin characteristics. These models can be used for predicting the effects of future land use changes on water temperature and suspended sediment concentration.

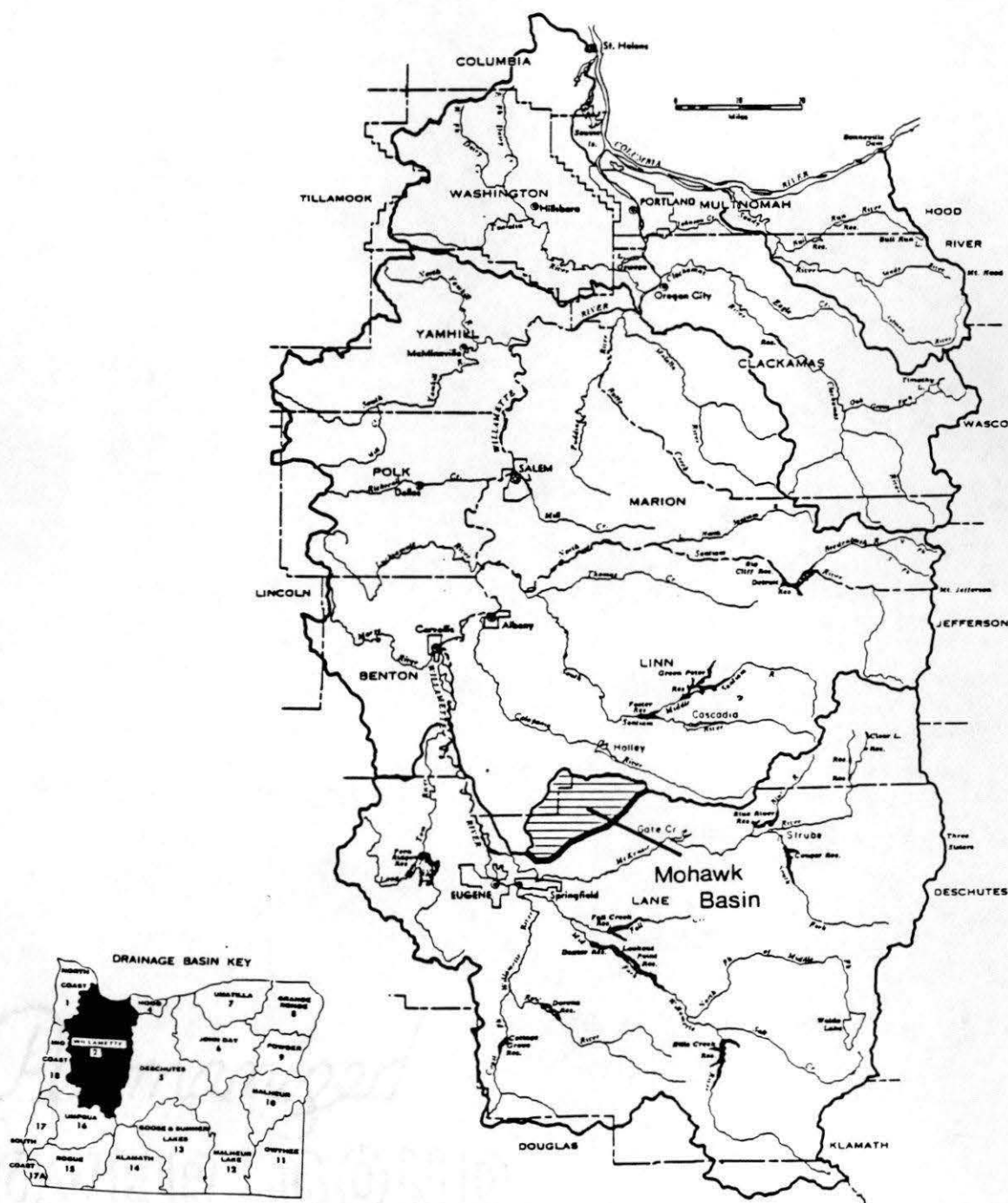


FIGURE 1. Location map of the Mohawk River Basin, Oregon. Source: State Water Resources Board. (1967). Willamette River Basin (p. 39 and Plate No. 1). Salem, OR.

Study Objectives

The objectives of this watershed study are:

1. To develop a base line data set for water temperature, suspended sediment, and land use in the Mohawk Basin;
2. To determine the relationship between land use and water temperature in the basin;
3. To determine the relationship between land use and suspended sediment concentrations in the basin;
4. To analyze spatially stream temperatures throughout the basin.

Paper Organization

Following this introductory chapter, a literature review is presented discussing water temperature, suspended sediment and the influence that land use has on them. The third chapter provides a descriptive overview of the Mohawk River Basin's topography, geology, soils, land use, climate, and streamflow. The fourth chapter discusses the methods of land use determination, site placement, sampling techniques, and types of statistical analysis employed. The fifth chapter presents the statistical findings of the temperature study. The sixth chapter presents the statistical findings of the suspended sediment study. The final chapter sums up the purpose of the study, the findings, the limitations, and

suggests ideas for further study.

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CHAPTER II

LITERATURE REVIEW

In order to give some background information on water temperature and suspended sediment, a review of the literature is provided in the following pages. First the relationship between water temperature and thermal energy is discussed. The solubility of oxygen is then related to stream temperature, followed by the influence of land use on dissolved oxygen concentrations and the importance of dissolved oxygen to the biotic community. Finally water temperature and the effects it has on anadromous fish and nitrogen gas saturation are presented.

In the second half of the chapter the capacity of a stream to carry sediment in suspension is related to the volume of flow and the availability of sediment to the stream environment. Soil disturbance and erosion accelerated by land use practice is then described. Erosion is discussed in terms of overland flow and mass movements. The chapter finishes with a section on buffer strip management.

Stream Temperature and Land Use

Stream Characteristics and Thermal Energy Exchange

The susceptibility of a stream to temperature variation is inherent in the characteristics of the individual stream (Brown, 1970c). Stream temperature is influenced by the water surface area, discharge, and bed of the stream. For this reason, shallow, wide streams heat up more rapidly than deep, narrow streams with the same streamflow or discharge. Small streams respond rapidly to temperature change because they have little thermal inertia (Brown, 1969). Change in stream temperature is inversely proportional to the volume of flow.

Incident solar radiation is the dominant energy source increasing water temperatures within unshaded reaches of small streams (Brown, 1969). Evaporation and convection are responsible for less than 10% of the energy exchanged within the stream environment. In shallow, clear streams, bedrock bottoms store 15-20% of the energy absorbed by the water and then release this thermal energy during the cool of the night, dampening the diurnal stream temperature fluctuation (Brown, 1970c). Gravel beds, on the other hand, are insignificant energy sinks (Brown, 1969).

Once heat energy has been absorbed by the stream, it is not readily dissipated but is stored as an increase in water

temperature (Brown, 1970b). Brown found that heated streams flowing through blocks of uncut timber did not cool even though net radiation incident to the stream was low. Lack of cooling was, in fact, due to the low quantity of energy exchanged by convection, evaporation, and/or conduction. Often the cooling of streams has been attributed to flow through shaded reaches when actually, significant changes in water temperature occurred where water sources with lower temperatures were introduced to the stream environment. This advective energy transfer may be in the form of precipitation, groundwater inflow, or tributary streams (Brown, 1969).

Effects of Stream Temperature

High water temperature is detrimental to the stream environment and its inhabitants. Deleterious effects are a decrease in dissolved oxygen, alteration of the life-processes of anadromous fish, supersaturation of water with nitrogen gas, increase in abundance of pathogens, modification of the effects of toxic materials, and increased algal growth. Only the first three harmful effects will be discussed here. Color, taste, and odor may also deteriorate as a result of elevated stream temperatures (Brown, Swank, & Rothacher, 1971).

Stream Temperature and Dissolved Oxygen

Both stream temperature and dissolved oxygen content are important regulators of biological activity within the stream (Brown, 1972). The solubility of oxygen in water is inversely proportional to the water temperature, so, as stream temperature rises, the concentration of oxygen falls. Channel roughness, slope, and cross-section influence the exchange rate of oxygen between the air and water. Microorganisms in the water also affect the concentration of dissolved oxygen. As these aquatic microorganisms feed on organic material in the stream, they utilize dissolved oxygen (DO) in the water. The amount of oxygen required for decomposition is called the biochemical oxygen demand (BOD). In direct response to increased temperatures, not only has the dissolved oxygen content decreased, but the biochemical reaction rate has increased (Mills, 1971). Thus dissolved oxygen concentrations present in the cool streams during the winter could be satisfactory, but warmer temperatures during the summer may reduce the dissolved oxygen content to little or none.

Logging practices affect the concentration of dissolved oxygen in water by introducing organic debris to the stream environment (Brown, 1972). Accumulation of large debris in streams may cause ponding which can elevate water temperatures through increased surface area. The presence of

small pieces of debris in the water puts a large demand on the DO content present. Leaves, needles, bark and small branches all provide simple sugars that are readily leached once in the water. These sugars are then decomposed by the microorganisms. Debris in streams also restricts flow, inhibiting the rate of reaeration.

Other problems that develop as a result of debris loading in streams are alteration of channel morphology and the creation of log jams impassable by anadromous fish. The need for successful anadromous fish migration is responsible for the mandate, by several western states, to remove woody debris from streams following logging operations (Bilby, 1984). This new debris is not often distinguished from older logs which have equilibrated with the stream environment, so removal of old debris can cause destabilization of channel banks as does the addition of new debris to the stream. Logging practices operating across streams also have the potential for damaging the stream environment. The removal of debris from streams can cause erosion problems and destruction of the riparian vegetation.

Large debris in streams also has beneficial effects. Large debris does not readily provide simple sugars for microbial decomposition as small debris does, and thus there is not the increased demand for dissolved oxygen. Studies have shown that large chunks of debris are beneficial in dissipating the potential energy of the stream, storing

transitory stream sediment, reaerating the water through falls, and providing camouflage for fish and other aquatic organisms.

Another important aspect of dissolved oxygen is its presence in the intragravel waters of the streambed. Anadromous fish eggs and alevins, developing seasonally within the gravel, depend on the availability of dissolved oxygen present. Once the quantity of dissolved oxygen within the intragravel water is reduced, the rate of intragravel reaeration is much slower compared to that of surface water reaeration (Hall & Lantz, 1969). Lantz (1970a) found that clearing the stream of debris following logging was enough to reoxygenate the surface waters once the rainy season began in autumn. He found, unfortunately, that the subgravel dissolved oxygen content remained below the pre-logging levels and had not yet recovered four years later. Depletion of the intragravel dissolved oxygen is partly caused by the long-term BOD of organic material present in the gravels and partly by the fine matter that has sedimented onto the gravels restricting water circulation through the gravels (Brown, 1972).

Stream Temperature and Anadromous Fish

Fish are cold-blooded animals whose bodies equilibrate in temperature to that of their external environment. Thus

water temperature, by influencing their body temperature, indirectly regulates the efficiency with which their bodily functions operate and their physical growth occurs. The effect of elevated stream temperature on anadromous salmonids depends on the stage of development within their life cycle (Reiser & Bjornn, 1979).

During the embryonic stage, increased water temperature can shorten this developmental period and so cause an early emergence of fry from their gravel beds (Bams, 1969). Migration downstream may be obstructed, or ocean conditions then may not be conducive to their growth and survival (Schmiege, Helmers, & Bishop, 1974). Elevated stream temperatures may also modify physical characteristics during the early stages of embryonic development (Orsaka, 1957; Seymour, 1959). Altered physical features may include the number of lateral line scales, vertebrae, fin rays, pharyngeal teeth, and gill rakers (Lantz, 1970b).

Upstream migration of adult salmonids can be delayed or prevented by unusual stream temperatures (Reiser & Bjornn, 1979). Sharp deviations from the normal temperature regimes experienced previously by the fish in their natal streams can deleteriously affect survival of adult salmonids during upstream migration. Outbreaks of disease, changes in migration timing, and altered rates of maturation may result from increased water temperatures. Reiser and Bjornn found that successful migration of selected salmonids occurred

within the range of 3° to 20° Celsius (C) (see Table 1). Successful spawning has taken place in waters ranging in temperature from 2.2° to 20 °C, depending on the species (see Table 2). Salmonids are cold water fish with a narrow preference range for stream temperature (see Table 3). Fish will acclimatize to increased temperatures, though they will die when they reach their physiological lethal limit (Klein, 1962; Mills, 1971). The lethal limit ranges narrowly from 23° to 25.8 °C. Normal activities of feeding, growth, reproduction, and competition may be hindered long before the

Table 1

Water Temperature Criteria for Successful Upstream Migration of Adult Salmon

Species of fish	Temperature range
Fall chinook salmon	10.6 - 19.4
Spring chinook salmon	3.3 - 13.3
Summer chinook salmon	13.9 - 20.0
Chum salmon	8.3 - 15.6
Coho salmon	7.2 - 15.6
Pink salmon	7.2 - 15.6
Sockeye salmon	7.2 - 15.6

Source: Bell, M. C. (1973). Fisheries handbook of engineering requirements and biological criteria. Useful factors in life history of most common species. Unpublished report, Submitted to Fish.-Eng. Res. Program, Corps of Engineers, North Pacific Division, Portland, OR.

Table 2

Recommended Temperatures for Spawning and Incubation of
Salmonid Fishes

Species of fish	Temperature °C Spawning	Incubation ^a
Fall chinook	5.6 - 13.9	5.0 - 14.4
Spring chinook	5.6 - 13.9	5.0 - 14.4
Summer chinook	5.6 - 13.9	5.0 - 14.4
Chum	7.2 - 12.8	4.4 - 13.3
Coho	4.4 - 9.4	4.4 - 13.3
Pink	7.2 - 12.8	4.4 - 13.3
Sockeye	10.6 - 12.2	4.4 - 13.3
Steelhead	3.9 - 9.4	---
Rainbow	2.2 - 20.0	---
Cutthroat	6.1 - 17.2	---

Source: Bell, M. C. (1973). Fisheries handbook of engineering requirements and biological criteria. Useful factors in life history of most common species. Unpublished report, Submitted to Fish.-Eng. Res. Program, Corps of Engineers, North Pacific Division, Portland, OR.

^aThe higher and lower values are threshold temperatures at which mortality will increase if exceeded. Eggs will survive and develop normally at lower temperatures than indicated, provided initial development of the embryo has progressed to a stage that is tolerant of colder water.

lethal thermal limit of the fish is reached (Klein, 1962). In waters reaching temperatures above 20.3 °C, metabolic activity increases and stops all growth of cold water fish (Bell, 1973). Many less desirable fish have a higher temperature tolerance level than do salmon or trout. Thus high temperatures may result in the proliferation of less

Table 3

Preferred, Optimum, and Upper Lethal Temperatures of Various Salmonids^a

Species	Preferred temperature range	Optimum temperature	Upper lethal temperature
Chinook	7.3 - 14.6	12.2 ^a	25.2
Coho	11.8 - 14.6	20.0 ^b	25.8
Chum	11.2 - 14.6	13.5 ^c	25.8
Pink	5.6 - 14.6	10.1	25.8
Sockeye	11.2 - 14.6	15.0 ^b	24.6
Steelhead	7.3 - 14.6	10.1	24.1
Cutthroat	9.5 - 12.9	--	23.0
Brown	3.9 - 21.3	--	24.1

Source: ^aBell, M. C. (1973). Fisheries handbook of engineering requirements and biological criteria. Useful factors in life history of most common species. Unpublished report, Submitted to Fish.-Eng. Res. Program, Corps of Engineers, North Pacific Division, Portland, OR.

^bKlontz, G. W. (1976). Fish health and management: concept and methods of aquaculture. Unpublished report, University of Idaho, Moscow.

^cBrett, J. R., Hollands, M., & Alderdice, D. F. (1958). The effect of temperature on the cruising speed of young sockeye and coho salmon. Journal of the Fisheries Research Board of Canada, 15(4), 587-605.

^dGarside, E. T., and Tait, J. S. (1958). Preferred temperature of rainbow trout (Salmo gairdner Richardson) and its unusual relationship to acclimation temperature. Canadian Journal of Zoology, 36, 563-567.

desirable fish at the expense of more desirable salmon or trout (Lantz, 1970b; Brown et al., 1971), desirability being based on sport and commercial fishing value.

Nitrogen Gas Supersaturation

As water temperature increases, the partial pressure of nitrogen gas (N_2) in solution declines; nitrogen gas comes out of solution supersaturating the water (Snyder, 1969). Therefore, when a cold fish moves to warm water and its body warms, N_2 comes out of solution in its bloodstream and forms bubbles that block the passage of blood to the heart.

Suspended Sediment and Land Use

The availability of sediment to the stream environment depends on the local geology, soils, topography, climate and land use. Surface erosion, mass wasting, and channel erosion all provide sediment to the stream under natural geologic conditions. Acceleration of these erosive and transportive processes can result from land use practices that disturb vegetative cover, destroy soil structure, and alter the natural hydrologic flow patterns of surface and subsurface water.

Flow and Sediment Concentrations

The accumulation of sediment in channels and on hillslopes during the summer low flow period provides sources of sediment readily available for transportation during the first major storms of the rainy season. These storms provide enough mechanical energy to entrain and transport sediment to lower elevations in the watershed where it will be deposited as the storm flow energy dissipates. A study of three small watersheds in the Oregon Cascades, by Rothacher, Dyrness, and Fredriksen (1967), revealed that water samples taken during early fall contained higher concentrations of sediment than samples taken under similar flow conditions during midwinter storms. Very few days, during the midwinter storms, had flows with high concentrations of sediment being transported. These few days were responsible for moving most of the total weight of suspended sediment from the watershed.

A number of articles noted that without large storm events occurring within the watersheds under study, high concentrations of suspended sediment did not take place even when land use practices were disturbing soil stability. Without the transport mechanism provided by rainfall, or mass movements, sediment loosened by land use will not be rapidly translocated from the area of disturbance to the stream environment. Rothacher et al. (1967), found that years deficient of large storms contained flows transporting low

concentrations of sediment, whereas the greatest concentrations of sediment were transported during years characterized by high flow conditions. Thus, without the flow energy provided by larger storm events, there will not be enough stream power available to entrain the sediments at rest within the channel or to maintain the particles already in suspension.

Soil Disturbance

Resistance to erosion varies with soil type, a product of parent material, climate, and vegetation. Disturbance of the protective vegetal ground cover can result in accelerated erosion of the soil resource. Vegetation protects the soil from raindrop impact, enhances infiltration, impedes overland flow, promotes soil structure, increases soil porosity, enriches the nutrient content, and binds the soil together. Soil compaction also accelerates the erosive process by destroying soil structure and so decreasing infiltration and increasing overland flow.

Surface Erosion and Land Use

Overland flow does not commonly occur on the highly porous soils of Oregon forest land except when the soil surface is severely disturbed (Brown, 1973). Forest and

agricultural practices along with wildfires set the stage for increased erosive activity. Road building, yarding, and slash burning associated with timber harvesting can accelerate erosive activity. Yarding is the gathering of logs into one area for the purpose of loading onto logging trucks. Increased quantities of suspended sediment in streams that have been influenced by land management activities often return to preharvest levels within a few years after the activity has ceased (Beschta, 1984).

Construction of logging roads creates an impermeable surface, concentrating water, and causing overland flow. Unchecked surface flow can deteriorate roads and adjacent surfaces by concentrating water into erosive channels that transport water and sediment to lower parts in the watershed. Studies have shown that felling trees does not increase suspended sediment and turbidity in streams, but that the removal of trees does (Megahan, 1976). Yarding roads and skid trails built and utilized for tree removal compact the soil surface and destroy the vegetation present.

Slash burning often follows tree removal in order to facilitate planting, to burn up scrubby vegetation and so provide room for the growth of new seedlings. Very hot slash fires and wildfires may accelerate erosion resulting in high sediment concentrations in streams (Brown & Krygier, 1971). The soil erosion potential varies with soil properties and the intensity of burn (Brown, 1973). Hot slash burns are

more destructive than cooler burns because more of the protective forest duff and litter layer are consumed. The presence of suspended sediment in streams depends not only on the area of soil bared by fire, but on the subsequent storm events which provide the mechanism for soil transportation (Anderson, 1965).

Mass Movements and Land Use

"The dominant erosional process on forest land in the Pacific Northwest is mass soil movement" (Sidle, 1980, p. 1). Mass movement is a general term for the gravitational displacement of soil, rock, and debris, either with or without the presence of water, air, or ice (Selby, 1982, p. 117). Mass movements occur naturally in response to geologic, topographic, vegetative, hydrologic, and climatic conditions. The alteration of these conditions by land use activities, such as road building and timber removal, tend to increase the frequency of their occurrence. The impact that mass movements have on the stream environment depends on whether or not they terminate in the stream or higher upslope. Movements which directly enter the stream provide readily transportable sediment and debris, whereas those movements remaining upslope provide soil for surface erosion rather than for immediate stream transport.

The 1964-65 Christmas storm event, which produced

prolonged periods of heavy rainfall in the Pacific Northwest, created numerous mass soil movements within the H. J. Andrews Experimental Forest. This provided an opportunity for an intensive study on the relationship of mass soil movements to land use and to natural site factors (Dyrness, 1967). Mass movements associated with road construction represented 72% of all failures. Seventeen percent of the mass movements were associated with logging disturbance, and 11% were in undisturbed areas.

Failures most commonly resulted from saturation of the road fill embankment. Road backslope failure results in road blockage and occurs when the soil mantle becomes saturated. These road backslope slumps may cause subsequent failure of the fill slope by altering the drainage pattern of the road, saturating the fill slope. Failure at several locations was in response to saturated soil material below the culvert outlet. Saturation of roadfill or sidecast material resulted in failure when the inside ditch or culvert became clogged with debris. Road failure also resulted when culverts carrying streams were of inadequate size or were blocked by debris.

Mass movement events occurring in logged areas were not explained by hydrologic alteration of drainage pattern, as in road failures, but are thought to have likely occurred even if the area had not been logged. "Although these movements took place in disturbed, logged areas, in every case it is

impossible to say whether the logging per se caused the instability" (Dyrness, 1967, p. 8). In an Alaskan study by Swanston, 1974, an increased percentage of slope failure, unrelated to roads, was associated with timber cutting and the subsequent deterioration of the slope stabilizing root system.

In the H. J. Andrews study, mass movements occurring in undisturbed areas were clearly associated with channel scouring. Here scouring occurred in response to the supersaturation and subsequent failure of the drainage headwalls (Dyrness, 1967). Channel scouring is the abrasive activity received by the channel environment as a result of debris torrents. "Debris torrents involve the rapid movement of water-charged soil, rock, and organic material down steep stream channels" (Swanston, 1976). Debris torrents can also be initiated by debris avalanches terminating in the stream or possibly by a change in the size distribution of debris within the channels; both mechanisms may occur in response to management activities (Swanson & Lienkaemper, 1978).

Mass soil movements in the western Cascades occur more frequently in pyroclastic materials, such as tuffs and breccias, than in terrain composed of andesite or basalt. Documentation of these mass failures further emphasized the relationship of mass movements to the instability of specific geologic materials: "64 percent of the mass movements were on greenish tuffs and breccias which make up only 8 percent

of the total area--clearly indicating the unstable nature of these materials" (Dyrness, 1967, p. 9).

Buffer Strips

In the past, both logging and agricultural practices have effected change in the stream environment by the alteration or removal of riparian vegetation. Streamside vegetation protects the stream by shading the water from direct solar radiation. In the Oregon Coast Range, one example of the effects of shade removal upon a stream environment took place in the completely clearcut watershed of Needle Branch. The maximum rate of net thermal radiation incident to the unshaded stream was more than 10 times that incident to a shaded stream in the patch-cut watershed of Deer Creek (Brown & Krygier, 1970). In July, the mean monthly maximum stream temperatures within the clearcut rose from a prelogging level of 13.9 °C (57 °F) in 1965 to that of 21.7 °C (71 °F) in 1967 following slash burning and stream clearance. Brown and Krygier determined that temperatures of completely exposed streams would closely approach prelogging temperatures within six years of the cut, if vigorous growth of vine maple, salmonberry, elderberry, and alder occurred.

Leaving buffer strips along streams is the management consensus for maintaining normal stream temperatures.

Because streams vary in character, the buffer strips must be

designed specifically for the individual streams. Stream dimensions, vegetation, aspect, topography, soils, geology, and climate must all be taken into consideration when designing a buffer strip.

Stream width, streamflow, canopy density, and canopy height together determine how wide a buffer strip needs to be in order to be effective (Brazier & Brown, 1973). Narrow stream channels can be protected as well by understory species, like salmonberry, as by merchantable timber (Brown et al., 1971). Brazier and Brown (1973), determined that angular canopy density, the density of foliage measured along the angle of incoming solar radiation, was the most important factor in determining the effectiveness of a buffer strip in controlling stream temperature. They further stated that buffer strip width alone does not ensure water temperature control, nor does the volume of commercial timber left standing within the strip determine the effectiveness on water temperature control.

Problems encountered in buffer strip management include blowdown, and damage from logging and disease. Blowdown of trees is the most common occurrence. According to Steinblums, Froehlich, and Lyons (1984), trees susceptible to windthrow are often down within the first couple of years following the harvest. They further found that buffer strip width did not significantly influence the stability of the trees. Trees that develop within open stands tend to be more

wind resistant than trees that develop under more dense and protected conditions (Fritzsche, 1933; Gradowski, 1956; Mergen, 1954). Mergen, 1954, stated that in order to become wind firm, trees must be exposed to wind while they are still young and before the main part of their growth is complete. This is because tree-bend from wind stress stimulates growth within the cambial layer of the stem and roots resulting in wind firmness. In live trees, the tensile strength on the windward side of the tree is stronger than the compressive strength on the leeward side of the tree. Therefore, when the root system is strong enough to prevent windthrow, and the wind stress exceeds compressive strength, the lower part of the trunk collapses (Mergen, 1954).

Resistance to windthrow has been related to tree species by Steinblums et al. (1984). In the Western Cascades, western redcedar was found to be most resistant to windthrow followed by western hemlock, Douglas-fir, and then the true firs. Their study further revealed that trees with above average height or diameter tended to be more vulnerable to windthrow, with the exception of true firs.

Buffer strip failure can result in greater water surface area exposed to direct solar radiation and thereby increase stream temperatures. Failure can also increase the accumulation of debris in stream channels. Subsequent mobilization of this debris during high flow can cause intense erosive activity directed toward streambanks, or

structural features downstream from the source. Thus, buffer strip design must be based on the site specific character of the stream and sub-basin.

CHAPTER III

BASIN CHARACTERISTICS

Within this chapter, the Mohawk River watershed characteristics of topography, geology, soils, land use, climate, and streamflow will be described. In addition, each section will briefly discuss the influence that these characteristics have on stream temperature and suspended sediment.

Topography

The North and South Forks of the Mohawk River head in the northeast corner of the basin where they join and flow southwestward 48.6 km (30.2 mi) to the McKenzie River as shown in Figure 2 (Note: mileage measured from top of the North Fork of the Mohawk River). A United States Geological Survey (USGS) gaging station for the Mohawk River is located 2.6 km (1.59 mi) up river from the McKenzie River confluence at a datum of 134.9 m (442.47 ft), recorded in 1929 as the National Geodetic Datum (USGS, 1984). Basin elevation rises to a maximum of 1,158.2 m (3,800 ft) in the headwaters of the South Fork of the Mohawk River. The valley floor, south of

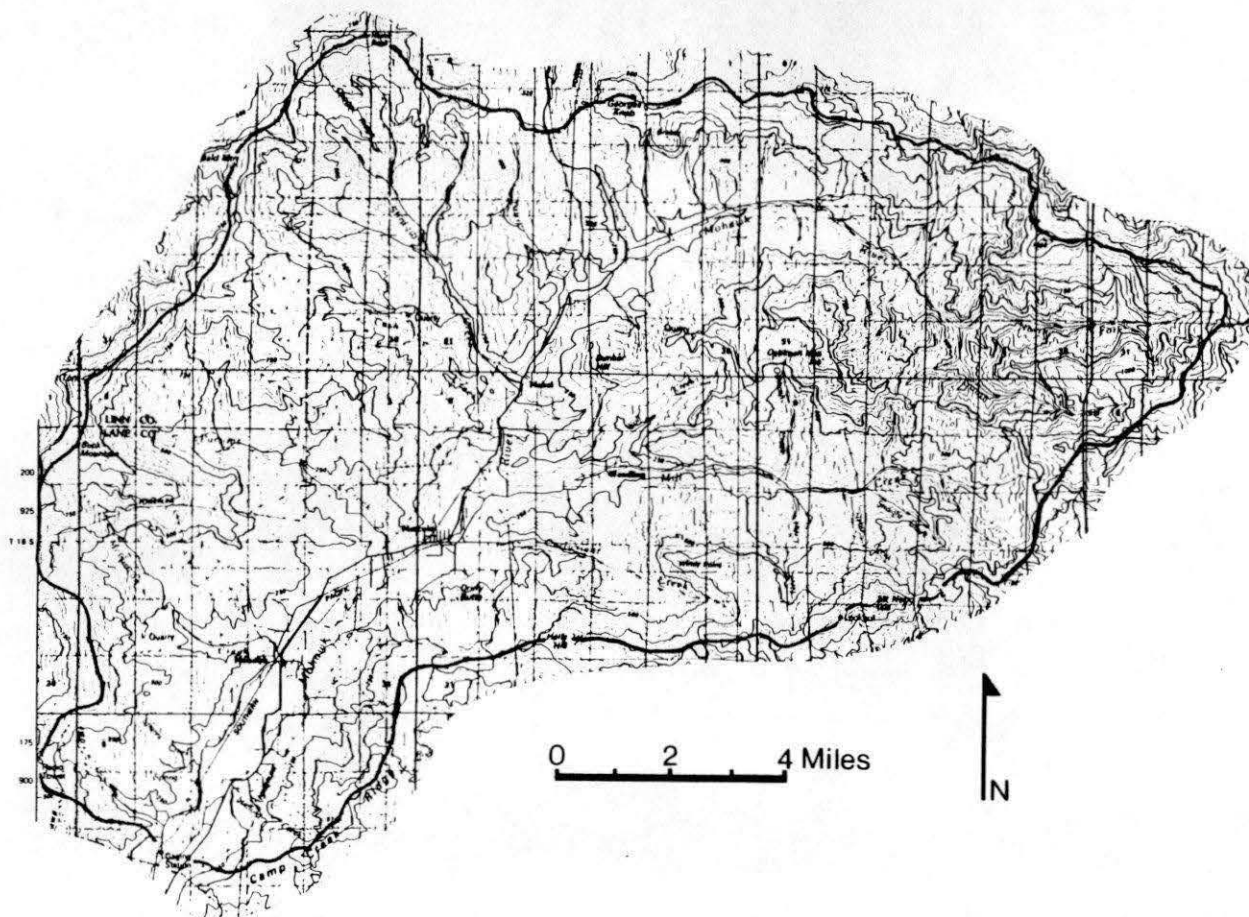


FIGURE 2. Topographic map of the Mohawk River Basin.
Source: USGS (1983). 1:100,000-scale metric
topographic map of McKenzie River, Oregon (No.
N4400 - W12200/30 X 60). Denver, CO.

Marcola, varies from 1.2 to 1.6 km (0.75 to 1 mi) in width, and reaches its maximum width of 2.4 km (1.5 mi) in the vicinity of Donna. Drainage basin parameters are shown in Table 4.

Within the stream, the advantage that steeper topography provides is that it readily aerates the water as it tumbles and falls to lower elevations. As a result, fish and other aquatic organisms benefit from the increased dissolved oxygen content. When precipitation rates exceed infiltration rates overland flow results. Particles of soil and other debris can then be detached and entrained by the overland flow resulting in surface erosion. Overland flow is not a problem in Oregon under natural forest conditions because of the highly porous soils present, unless the soil surface is severely disturbed (Brown, 1973). Mass wasting is another erosion problem associated with steep topography. Slopes beyond the the angle of repose are vulnerable to rock falls, slides, and other mass movements.

Geology

The Mohawk River Basin lies adjacent to the Willamette Valley in the foothills of the Western Cascade Range. The Cascades are a north-south trending volcanic chain two-thirds of which forms the Western Cascades and one-third of which forms the High Cascades (Weissenborn, 1969). The Western

Table 4

Mohawk River Drainage Basin Parameters

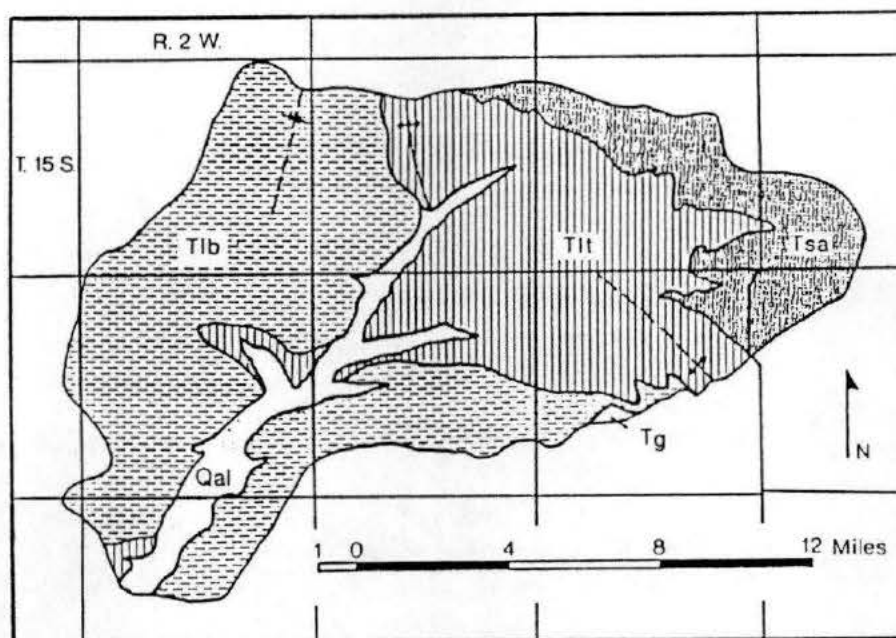
Total basin area	458.4 km ²	178.5 mi ²
Basin relief	1,024.1 m	3,360 ft
Mohawk channel length	46.3 km	28.8 mi
Mohawk channel slope	2 %	
Total basin channel length	1,407.6 km	874.8 mi
Basin drainage density	3.0 km/km ²	4.9 mi/mi ²

Note. Station X1 is the lower boundary for these measurements.

Cascades are predominantly composed of partially altered and slightly deformed volcanic flows and pyroclastic rocks ranging in age from late Eocene to late Miocene. The faulted and eroded eastern edge of the Western Cascades has since been partially buried by a younger chain of coalescing shield volcanoes composed of basalt and basaltic andesite, which provide the base for the overlying large, andesitic composite volcanoes that form the crest of the High Cascades.

The Mohawk River is a tributary to the McKenzie River which originates in the High Cascades. Glaciers have modified the morphology in the upper 48.3 to 64.4 km (30 to 40 mi) reach of the McKenzie River with U-shaped valleys and morainal deposits (Weissenborn, 1969), but there is no evidence of glaciation in the Mohawk River Basin.

Figure 3 is a Geologic Map of the Mohawk River Basin revealing the presence of both extrusive and intrusive



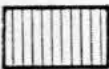
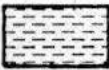
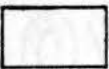
- | | | |
|---|-----------|--|
|  | Tlt | Little Butte Volcanic Series, tuff, lapilli tuff, and less abundant domes and flows of dacite, andesite and rhyodacite |
|  | Tlb | Little Butte Volcanic Series, basaltic andesite and olivine basalt flows |
|  | Tsa | Sardine Formation, pyroxene andesite and less abundant basalt and dacite; flows, tuff breccia, lapilli tuff, and tuff |
|  | Tg | Granodiorite, quartz monzonite, quartz diorite, and diorite; stocks, pipes, and dikes |
|  | Qal | Alluvium, Stratified silt, sand, and gravel; undifferentiated. Recent alluvium and Pleistocene Willamette Silt and terrace deposits. |
|  | Anticline | |
|  | Syncline | |

FIGURE 3. Geologic map of the Mohawk River Basin. Source: Peck, D. L., Griggs, A. B., Schlicker, H. G., Wells, F. G., & Dole, H. M. (1964). Reconnaissance Geologic Map and Sections of the Western Cascade Range North of Latitude 43. Geological Survey Professional Paper, 449.

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volcanic rocks in the basin (Peck, Griggs, Schlicker, Wells, & Dole, 1964). The Little Butte Volcanic Series covers the majority of the basin and is represented by flows of basaltic andesite and olivine basalt, and by tuff, lapilli tuff, and less abundant domes and flows of dacitic andesite and rhyodacite. The Sardine Formation is present in the northeastern corner of the basin and is represented by pyroxene andesite and less abundant basalt and dacite in the form of flows, tuff breccia, lapilli tuff, and tuff. Intrusive rocks are present on Mt. Nebo, which is composed of granodiorite, quartz monzonite, quartz diorite, and diorite. Alluvium is present on the Mohawk Valley floor and in the lower reaches of several tributaries.

The most obvious effect of bedrock substrate on water temperature is the potential to store thermal energy within the rock mass and later release the energy after the sun goes down. Mill Creek is one location within the basin where water flows over a bedrock bottom. Geology also influences the availability of sediment to the stream environment. Rocks vary in their rate of chemical and mechanical weathering, thus defining the inherent stability or instability of a rock formation and its potential for mass wasting.

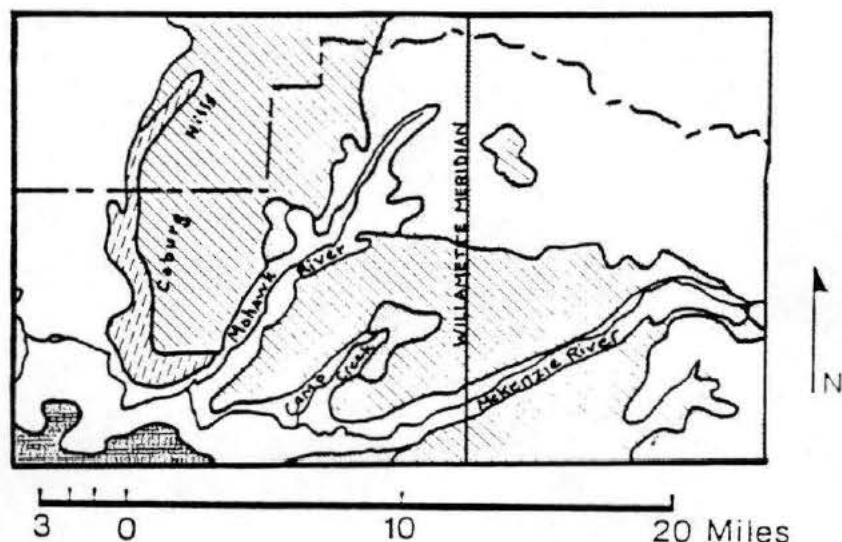
Within the Mohawk Basin, the Sardine Formation (Tsa) and the Little Butte Series tuffs (Tlt) have the greatest potential for mass movement. The Sardine Formation is

present in the northeastern part of the basin and has a moderate potential for mass movement (Schlicker and Finlayson, 1979). The Little Butte Series tuffs (Tlt) are present in the southeastern part of the basin and extend into the McKenzie Basin in the vicinity of Leaburg Dam, where in 1986 a mass movement occurred in response to heavy rainfall and temporarily blocked highway 126 and knocked a house off its foundation. In 1987, mass movement again occurred at the same location, though it was not associated with rainfall.

Figure 4 is an erosion potential-sediment yield map for the Mohawk River Basin and surrounding area (ODEQ, 1978). The map reveals soil and rock stability as related to precipitation. Channel and floodplain deposits are shown to have a moderate erosion potential because of the poor drainage present in some areas. A large portion of the basin is covered by relatively stable rocks, which when afforded the protection of vegetal cover have a low potential for mass wasting even under moderate precipitation. The northeast corner of the basin is occupied by rocks (primarily Little Butte Tuffs and Sardine Formation) prone to mass wasting. The inherent instability of these rocks, along with high precipitation rates, provide the potential for greater quantities of sediment to be introduced to the stream environment as compared to other areas of the basin.

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EXPLANATION



Urban



Alluvial Soils of Western Oregon. The soils are dominantly deep and silty and many are poorly drained. Slopes range from 0-7 %, and surface erosion potential is moderate.



Relatively Stable Rocks in Areas of Moderate or High Precipitation. Precipitation averages 20 inches or greater. The rock characteristics and the protection afforded by undisturbed vegetative cover result in a low natural potential for slumps, surficial landslides, and deep bedrock slides.



Rocks Prone To Mass Wasting in Areas of Moderate Precipitation. The rock characteristics and moderate precipitation result in a moderate to high potential for slumps, surficial landslides, and deep bedrock slides.



Rocks Prone to Mass Wasting in Areas of High Precipitation. Annual precipitation exceeds 60 inches. The rock characteristics and high precipitation results in a high potential for slumps and surficial landslides.

FIGURE 4. Erosion Potential-Sediment Yield Map for the Mohawk River Basin and surrounding area. Source: State of Oregon Department of Environmental Quality (1978). Erosion Potential-Sediment Yield Map, Oregon's Statewide Assessment of Nonpoint Source Problems.

Soils

The effect that soils have on suspended sediment depends on their erodibility, permeability, and the presence of vegetation. Table 5 lists the soil associations present within the basin and describes them in terms of texture, natural drainage, permeability, runoff, and erosion hazard. Figure 5 is a map showing where these soil associations occur in the basin. The Peavine-Honeygrove-McCulley (PHM) soil association is present over 47% of the basin and occupies terrain at higher elevations. The Kinney-Bohanon-Klickitat (KBK) soil association covers 23% of the basin and dominates the highest elevations. The Nekia-Bellpine-Ritner (NBR) soil association represents 19% of the basin and covers the lower slopes adjacent to the valley floor. The Abiqua-McAlpin (AM) soil association dominates the valley floor and represents 7.6% of the basin soils. The Waldo-McAlpin (WM) soil association and the Philomath-Hazelhair-Bellpine (PHB) soil association are found only in pockets along the valley floor in the southwestern part of the basin and together represent just over one percent of the basin soil.

Soils within the Mohawk Basin have a shrink-swell potential that ranges from low to high. The shrink-swell potential indicates the stability of a soil. A soil with a high shrink-swell potential can readily adsorb water thus

Table 5

Soil Association Description and Hydrologic Characteristics

SOIL ASSOCIATION	DESCRIPTION	NATURAL DRAINAGE
ABIQUA MCALPIN	silty clay loam over silty clay soils	somewhat excessive to poor
WALDO MCALPIN	silty clay loam over silty clay soils	good to poor
PHILOMATH HAZELAIR BELLPINE	silty clay loam over clay soils	good to somewhat poor
NEKIA BELLPINE RITNER	silty clay loam over clay soils & cobbly silty clay loams over very cobbly clay soils	good to somewhat poor
PEAVINE HONEYGROVE MCCULLEY	silty clay & clay loams over silty clay soils	good
KINNEY BOHANNON KLICKITAT	cobbly loam over cobbly clay loam soils	good

Source: Lane County Commissioners in Cooperation with USDA
Soil Conservation Service and Oregon State University (1971).
Lane County Soils Association Map with interpretive guides.

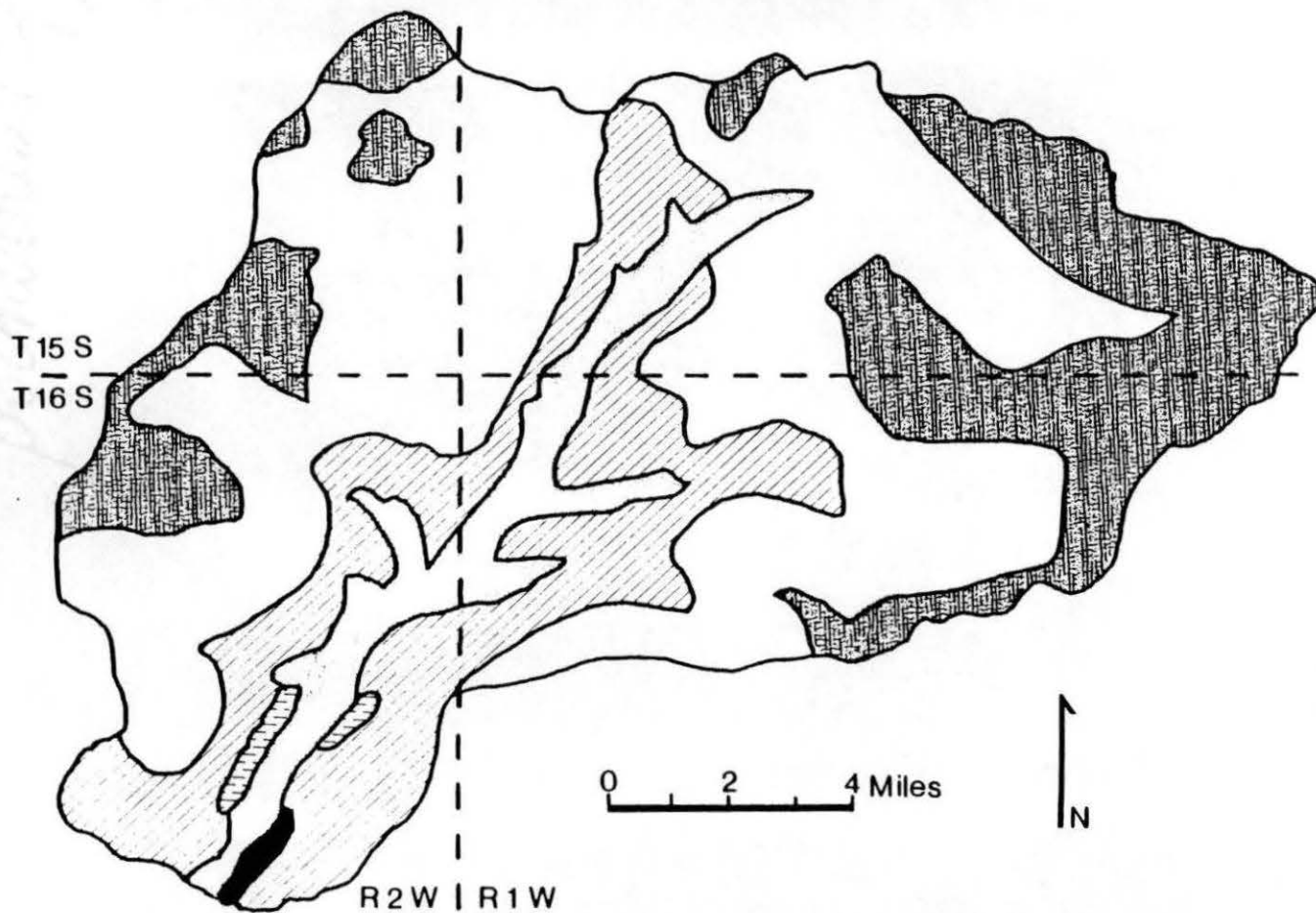
Table 5 (Continued)

PERMEABILITY	RUNOFF	EROSION HAZARD	HYDROLOGIC GROUP
very slow to moderately rapid	medium to ponded	slight to moderate (overflow)	B C
very slow to moderate	medium to ponded	slight to moderate (overflow)	D C
very slow to moderately slow	slow to rapid	slight to severe	D D C
slow to moderately slow	slow to rapid	slight to severe	C C C
very slow to moderate	slow to rapid	slight to severe	C B C
moderate to rapid	slow to rapid	slight to severe	B C B

FIGURE 5. Mohawk Basin soil association map. Sources: Lane County Commissioners (1971). Lane County soils map with interpretive guides; Lane County Commissioners in Cooperation with USDA Soil Conservation Service and Oregon State University. Soil Conservation Service (1985). Linn County area, Oregon general soil map. USDA. SCS. Oregon Agriculture Experiment Station, USDI, BLM.

SOIL ASSOCIATION

- | | |
|---|-------------------------------|
|  | 1 Abiqua-McAlpin |
|  | 2 Waldo-McAlpin |
|  | 3 Philomath-Hazelair-Bellpine |
|  | 4 Nekia-Bellpine-Ritner |
|  | 5 Peavine-Honeygrove-McCulley |
|  | 6 Kinney-Bohanon-Klickitat |



reducing the shear strength of the soil by weakening its internal structure (Selby, 1982). The Little Butte Volcanic Series (Tlt) is the parent material in which the Peavine-Honeygrove-McCulley soil association developed. As discussed in the previous section on geology, the Little Butte Volcanic series is the geologic material that experienced recent mass movements adjacent to the Mohawk Basin. All three of these soils have moderately deep to deep, well drained profiles that have formed in colluvial and residual material. The shrink-swell potential is low to moderate in the Honeygrove series, moderate in the Peavine series, and moderate to high in the McCulley series. The Sardine Formation is the parent material in which the KBK soil association has developed. This association has a low shrink-swell potential. The western edge of the Little Butte series (Tlt) is the parent material for the NBR association which has a low to moderate shrink-swell potential. The soil associations of AM and WM have developed on alluvial material and have a high shrink-swell potential. The PHB soil association has also developed on alluvium near the mouth of the Mohawk River and its shrink-swell potential ranges from low to high.

Soil erodibility can also be described in terms of hydrologic soil groups (see Table 5) (SCS, 1987). Here soils are categorized according to runoff and the inherent infiltration capacity of bare soil. Vegetation and slope are

not a part of the criteria. There are four hydrologic soils groups ranging from group A representing soils with a high infiltration rate and a low runoff potential under wet conditions, to group D where the rate of infiltration is very slow producing a high runoff potential.

Soil associations WM, PHB, and NBR represent the hydrologic groups of C and D with low infiltration rates and high runoff potential. These soils are present along the outer floodplain and the lower flanks of the Mohawk valley. When under the influence of storm events, runoff from these soils has the ability to dislodge and entrain soil particles and transport them to the stream environment where they will become a part of the suspended sediment load. The extent of erosion will depend on the land use. Within the Mohawk Basin, soil associations WM and PHB support non-forest (agricultural and residential) land use. Soil association NBR is covered by forest and cut-over land.

The AM soil association falls into the hydrologic groups of B and C where the alluvial sediments are moderately drained. Non-forest land occupies these soils.

Soil associations PHM and KBK are also in the hydrologic groups of B and C. The soils are found on the steep slopes of the upper watershed where they support forest and cut-over land. Infiltration on these soils varies from slow to rapid. Soils with slower infiltration rates and greater runoff rates have the potential of providing a

greater amount of sediment to the stream environment.

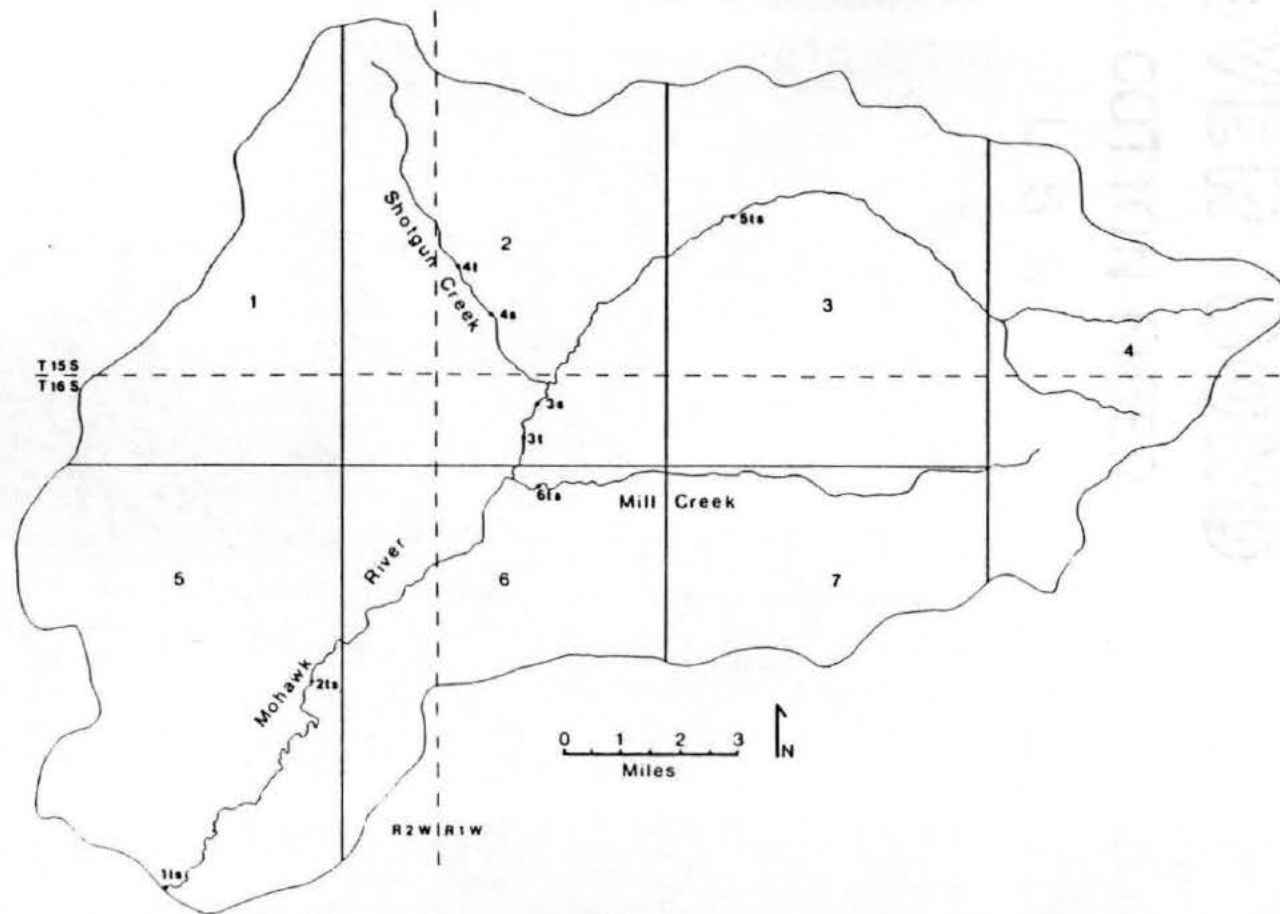
In summary, the geologic formations most susceptible to mass movement include the Sardine Formation (Tsa) and the Little Butte Series (Tlt). Mass movements and surface erosion are also related to the shrink-swell potential of the soil. Soil associations with a moderate to high shrink-swell potential include PHM, NBR, AM, WM, and PHB. In terms of hydrologic soil groups, the soil associations of WM, PHB, and NBR, all have low infiltration rates and high runoff rates making these soils readily susceptible to surface erosion. Soils throughout the watershed are more susceptible to surface erosion and mass movements where vegetation has been altered or destroyed and where topography is of steep relief.

Land Use

The Mohawk Basin was split into seven sections, as seen in Figure 6, in order to show land use on a large scale. Figures 7 through 13 are land use maps showing forest, cut-over, agricultural, and residential areas. Methodology used in the development of these land use maps is explained in chapter IV. Most of the valley floor is occupied by agricultural lands, which represent 6.38% of the entire basin area. Residential areas, also on the valley floor, comprise less than 1% of the basin area. The only towns in the basin are Marcola and Mohawk, each of which has a population of

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FIGURE 6. Index to land use map. (Note: basin map is divided into seven sections which will be enlarged to show land use (see Figures 7 through 13).



LAND USE EXPLANATION

-  Agriculture
-  Residential
-  Forest cover
-  Cut-over

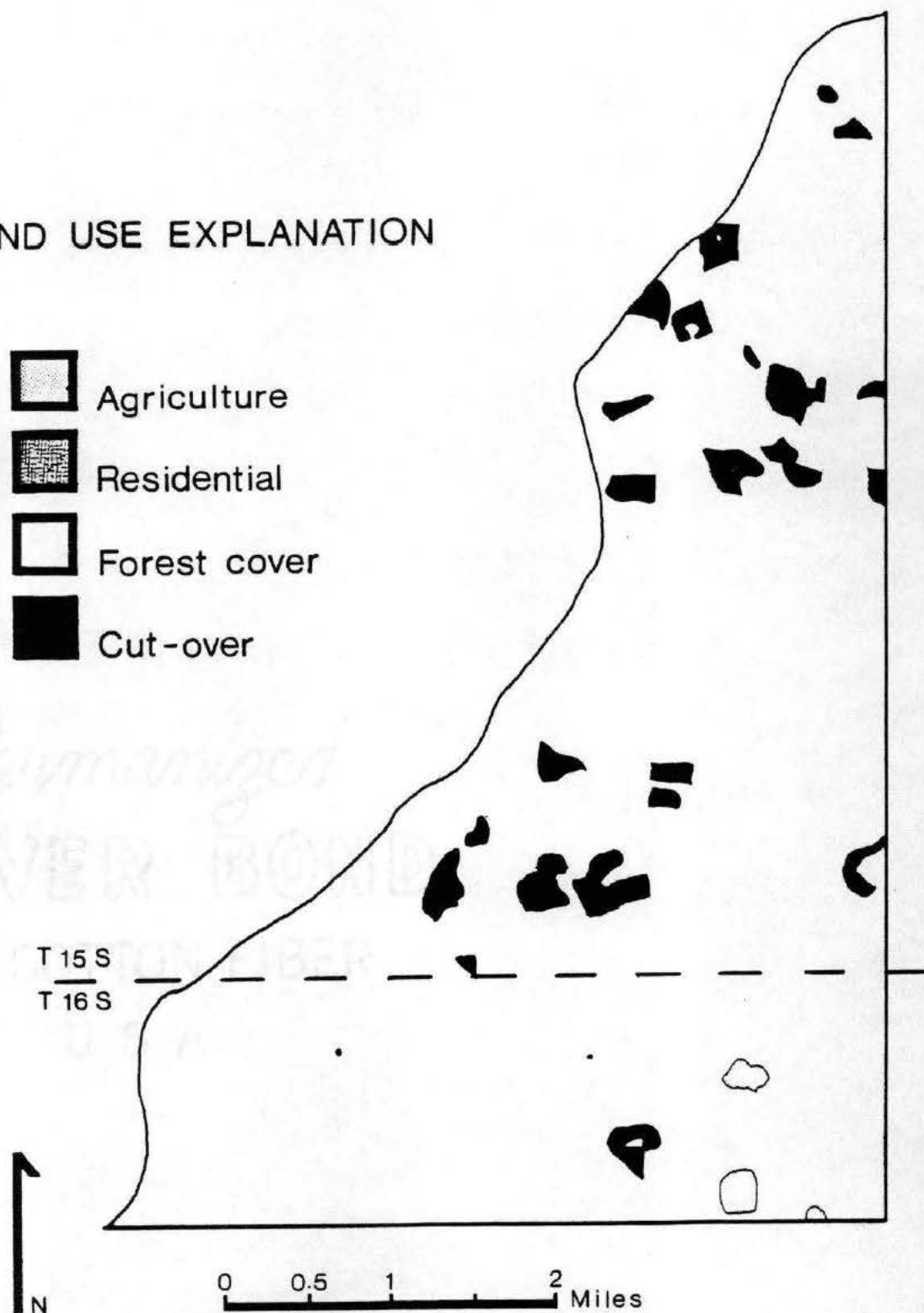


FIGURE 7. Land use map section 1.

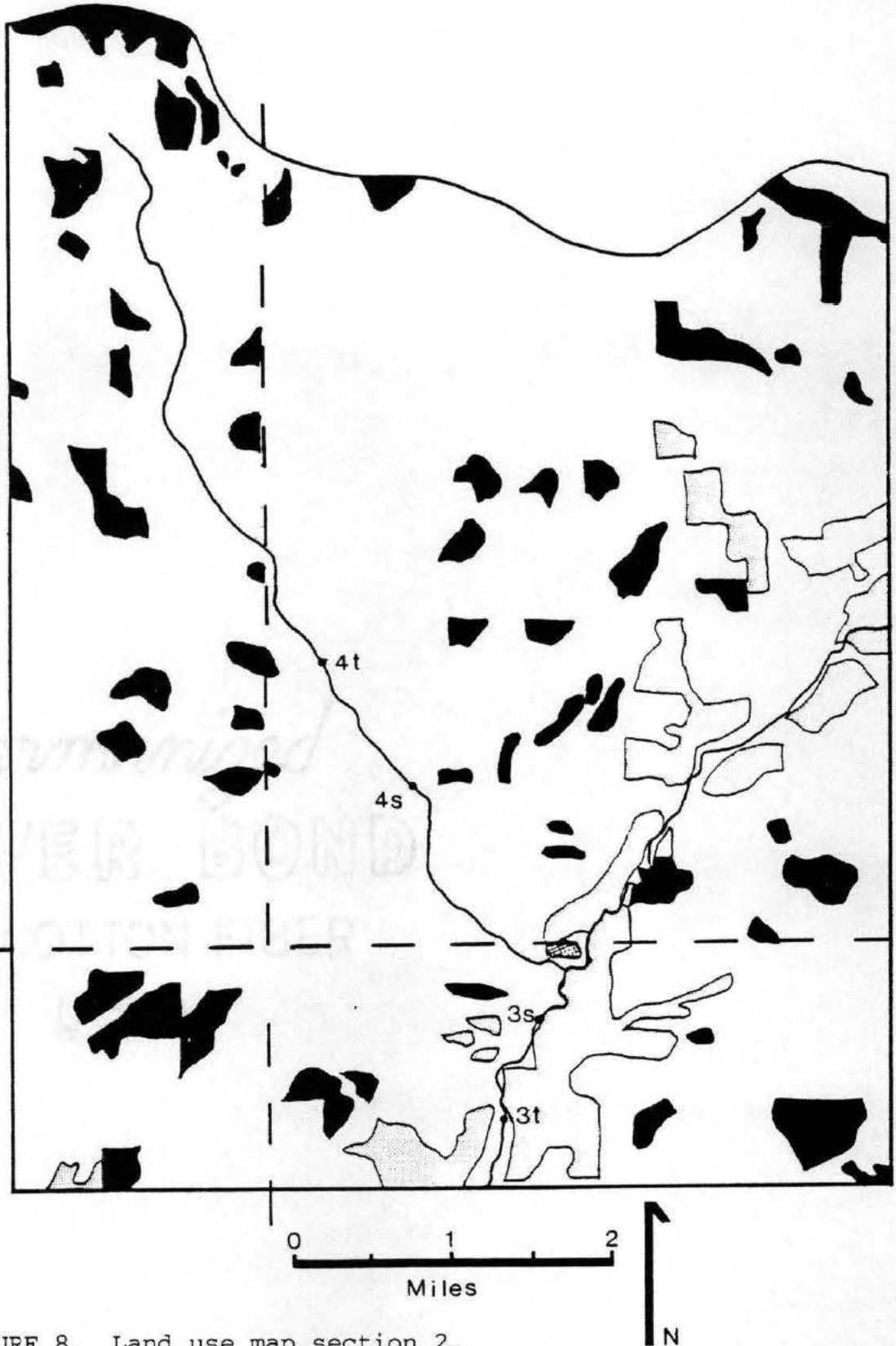


FIGURE 8. Land use map section 2.

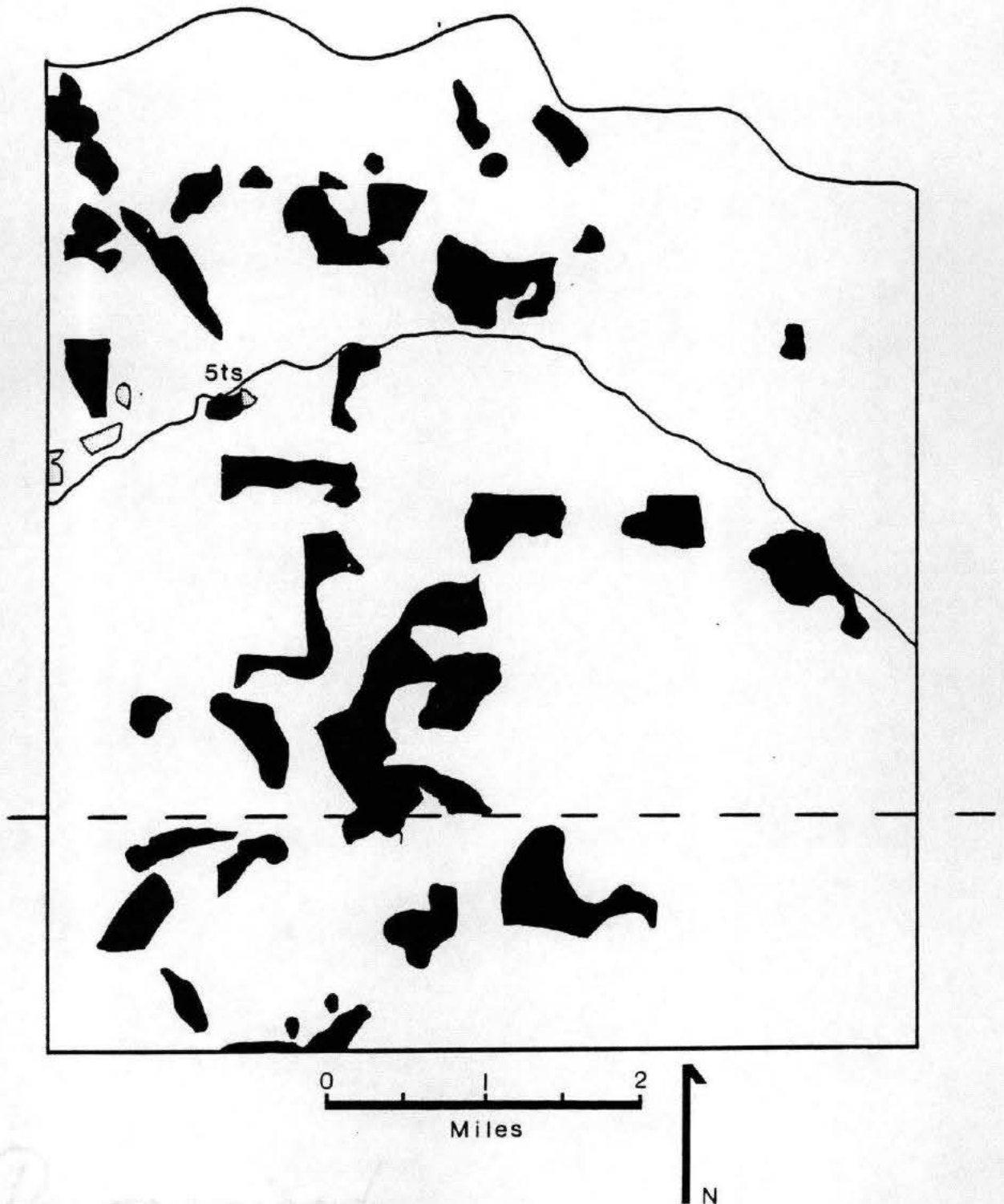


FIGURE 9. Land use map section 3.

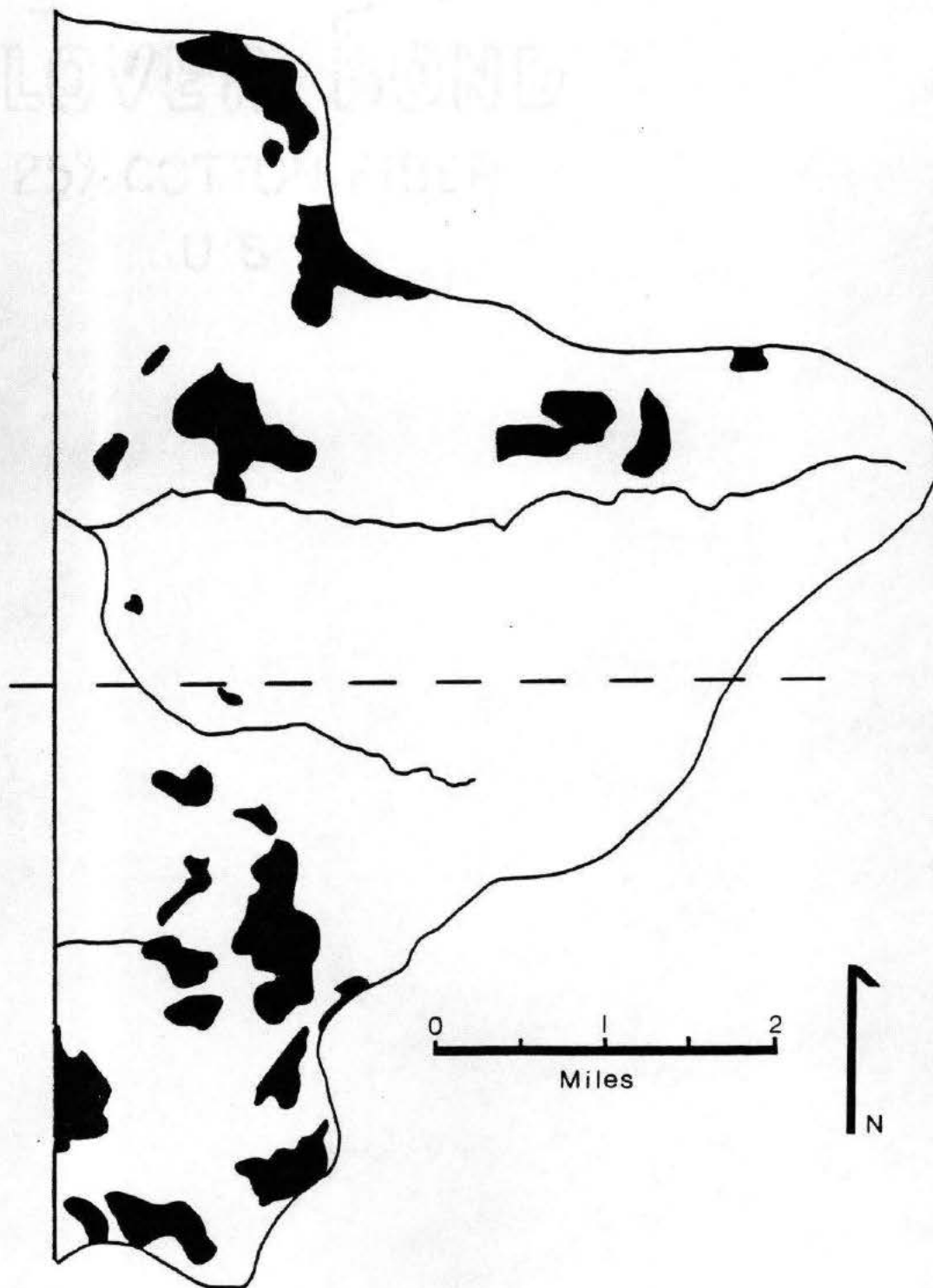


FIGURE 10. Land use map section 4.

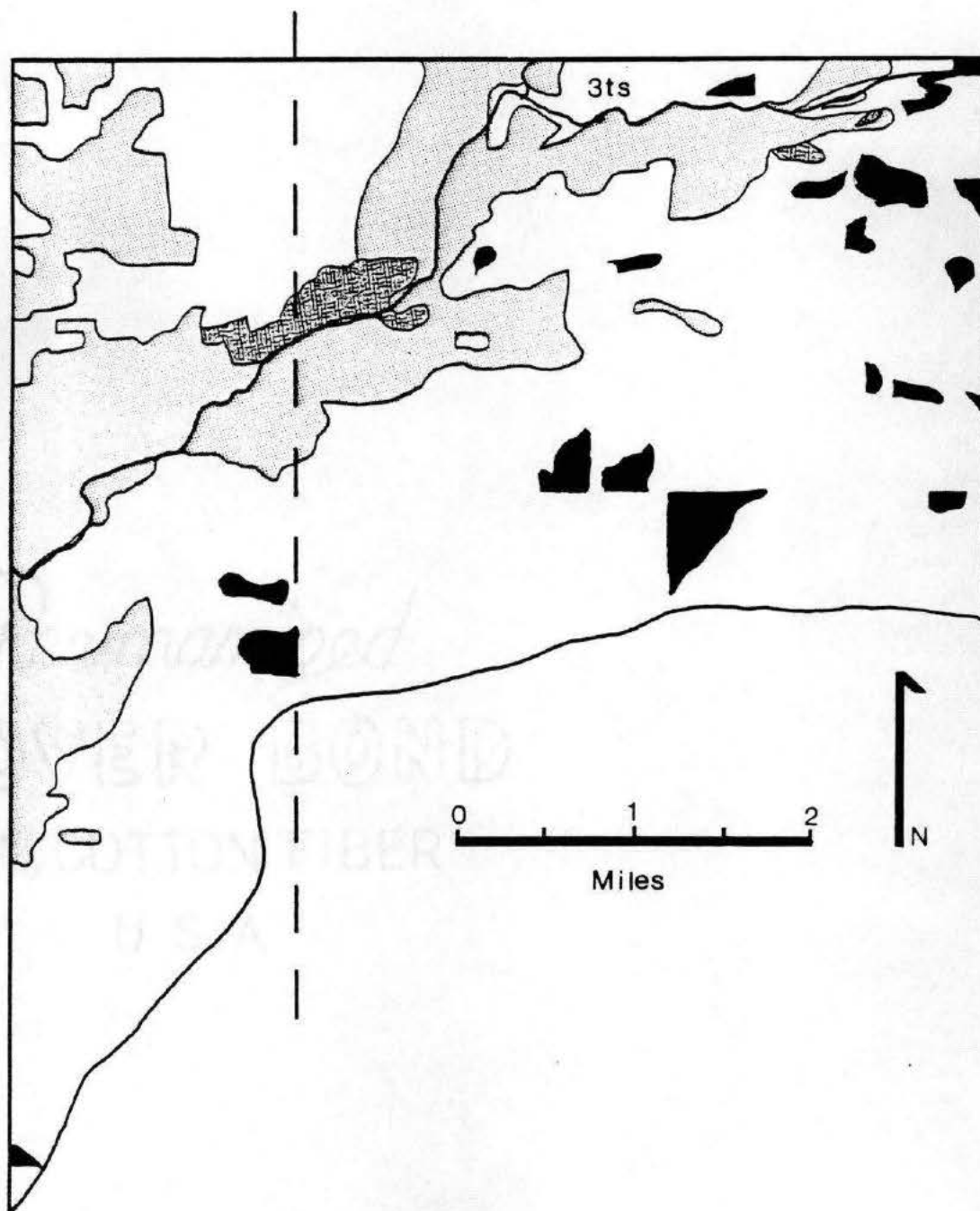


FIGURE 12. Land use map section 6.

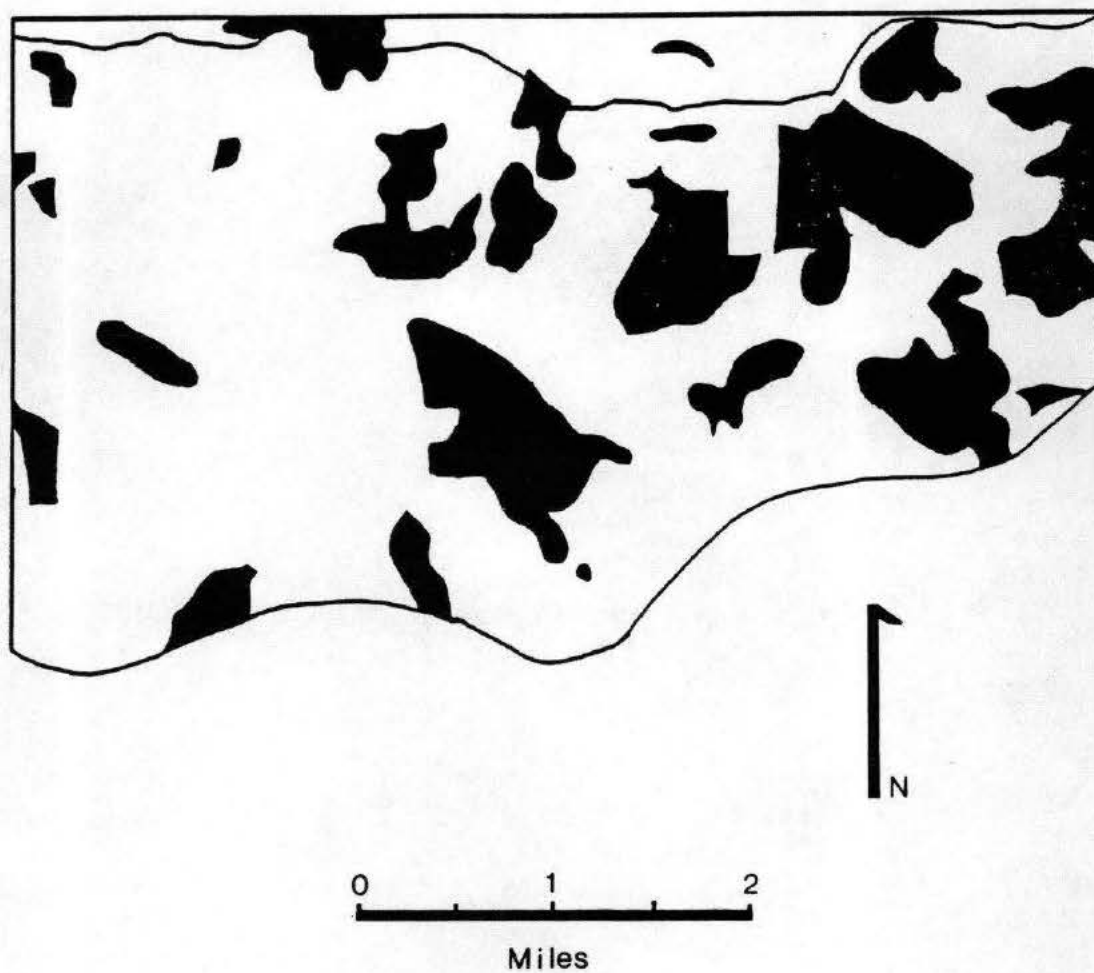


FIGURE 13. Land use map section 7.

less than 250 people. Forests cover 86.6% of the land and extend from the flanks of the valley floor up to the drainage basin divide. Timber cut-over areas comprise 6.82% of the land area and are scattered throughout the forested regions of the basin.

The influence of land use on water temperature and suspended sediment is determined by the extent of soil disturbance and vegetative manipulation, and is covered in the literature review of chapter 2.

Climate

The Mohawk River Basin is under the influence of a Mediterranean climate, with dry summers and wet winters. During the dry summer season, drought commonly occurs when evaporation rates exceed rainfall rates. November through March is when 70% of the annual precipitation falls (BLM, 1976). Within the basin, average annual precipitation increases with elevation from 127 cm per year (50 in/yr) near the mouth of the Mohawk River to 203 cm per year (80 in/yr) in the headwaters (see Figure 14) (SWRB, 1961). The amount, duration, and seasonal distribution of precipitation, both rain and snow, determines the quantity of streamflow throughout the year. Snowfall is not significant in the basin and does not augment spring and summer streamflow, as in the higher elevations of the Cascades.

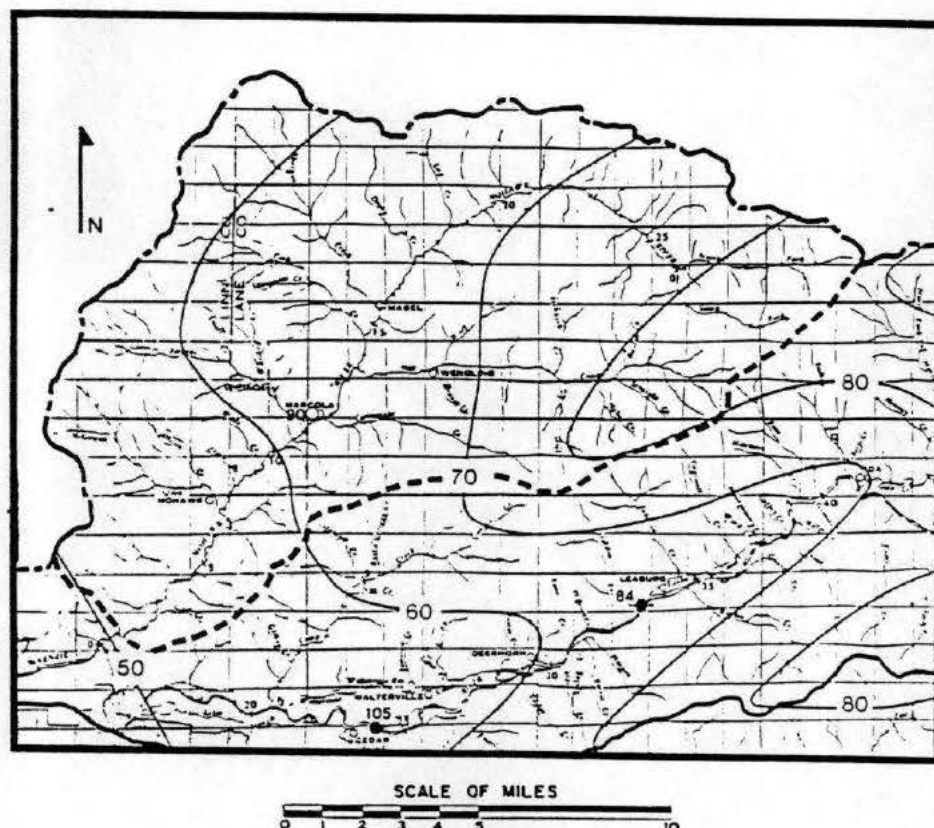


FIGURE 14. Map of the average annual precipitation occurring in the Mohawk Basin in inches per year. Source: State Water Resources Board (1961). Upper Willamette River Basin (Plate No.3). Salem, OR.

Streamflow

Streamflow is a combination of groundwater inflow and surface runoff in response to precipitation events. During the dry summers, streamflow depends on groundwater for baseflow. This season of low flow allows for rapid heating of water and elevated water temperatures. Summer days with overcast skies can help to buffer water temperature changes in streams by scattering the incoming direct solar radiation.

Figure 15 shows a mean monthly hydrograph for the Mohawk River at station 1 based on USGS stream flow data for the water year period of 1964 to 1984, and the water years of 1986, and 1987. The 1964 to 1984 hydrograph represents the averaged mean monthly discharge for that 20 year period, and shows a broad curve which takes into account the monthly variations in discharge over the years. The single water years of 1986 and 1987 both peak in February as compared to the averaged hydrograph which peaks from December through January. August and September of water year 1986 were the months when I collected my water temperature data. In August 1986, the Mohawk River had a below average flow of 23.5 CFS (cubic feet per second), the average being 39.6 CFS. October through March of water year 1987 were the months when I collected water samples for suspended sediment and turbidity measurements. A comparison of water year 1987 to the averaged water years revealed that peak discharge occurred

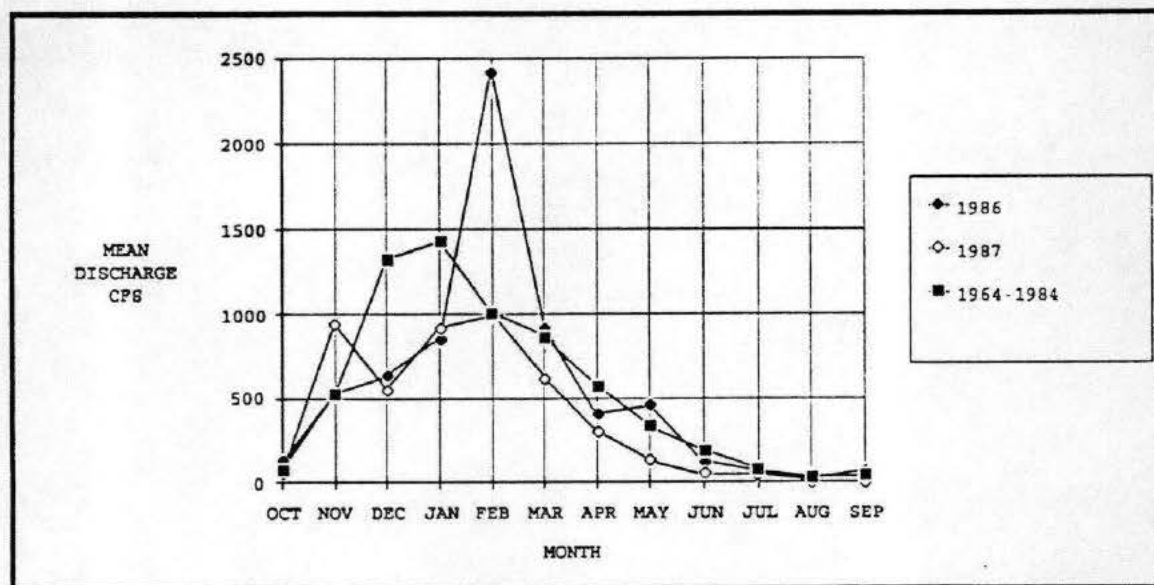


FIGURE 15. An overlay of the mean monthly hydrographs for water years 1986, 1987, and for the averaged means for the period of 1964 to 1984. Source: United States Geological Survey. (1964-87). Water Resources Data Water Year(s) 1964-1987, Vol. 2. Western Oregon (Report No. OR-(64-87)-2). Portland, OR.

roughly a month to two months later than average. Likewise, discharge was much lower during December and January of water year 1987 than for the period of 1964 through 1984. Water year 1986 far exceeded the peak discharges of 1987 and the averaged means of the period of 1964 through 1984, with a discharge of 2414 CFS.

The lower than average discharge for August and September of 1986 allowed for the more rapid heating of water temperatures by solar radiation. Discharge during suspended sediment sampling in 1987 was equal to or lower than the average year, excluding November when discharge was above average. A higher discharge provides the potential for a greater suspended sediment carrying capacity, thus November was the month of greatest suspended sediment transport within the basin as shown in Table 25 in Appendix B.

CHAPTER IV

METHODOLOGY

I begin this chapter by discussing how land use categories were determined, how temperature and water sampling sites were selected, and where the sites are located. The section on temperature data collection describes the criteria for placement of thermometers within the stream, the recording frequency, and the temperatures recorded. The section on suspended sediment collection discusses the methods of collecting water samples for suspended sediment and turbidity analysis, and of obtaining velocity readings for discharge determination. The final section discusses the statistical methods employed; these include linear regression analysis using Mallows' C_p statistic to help select individual regression models.

Land Use Determination

Land use was determined from 1984 aerial photograph coverage provided by the BLM. Land use was classified into four categories: (a) forest cover, (b) cut-over forest, (c) agriculture, and (d) residential. Forest cover represents

currently forested areas, old revegetating clearcuts, and balds. Cut-over forest land includes recently logged areas and areas with older cuts that have not revegetated enough to cover bare soil. Agricultural land represents open fields along the valley floor. Residential area is defined by houses and other buildings seen on aerial photographs. Agricultural land and residential areas were combined in the analysis to form the category of non-forest land.

The percentage of land representing each use was quantitatively determined by digitizing the land use map using a BLM traverse program on an HP 520 computer. The traverse program calculates the area within a unit given the boundary coordinates.

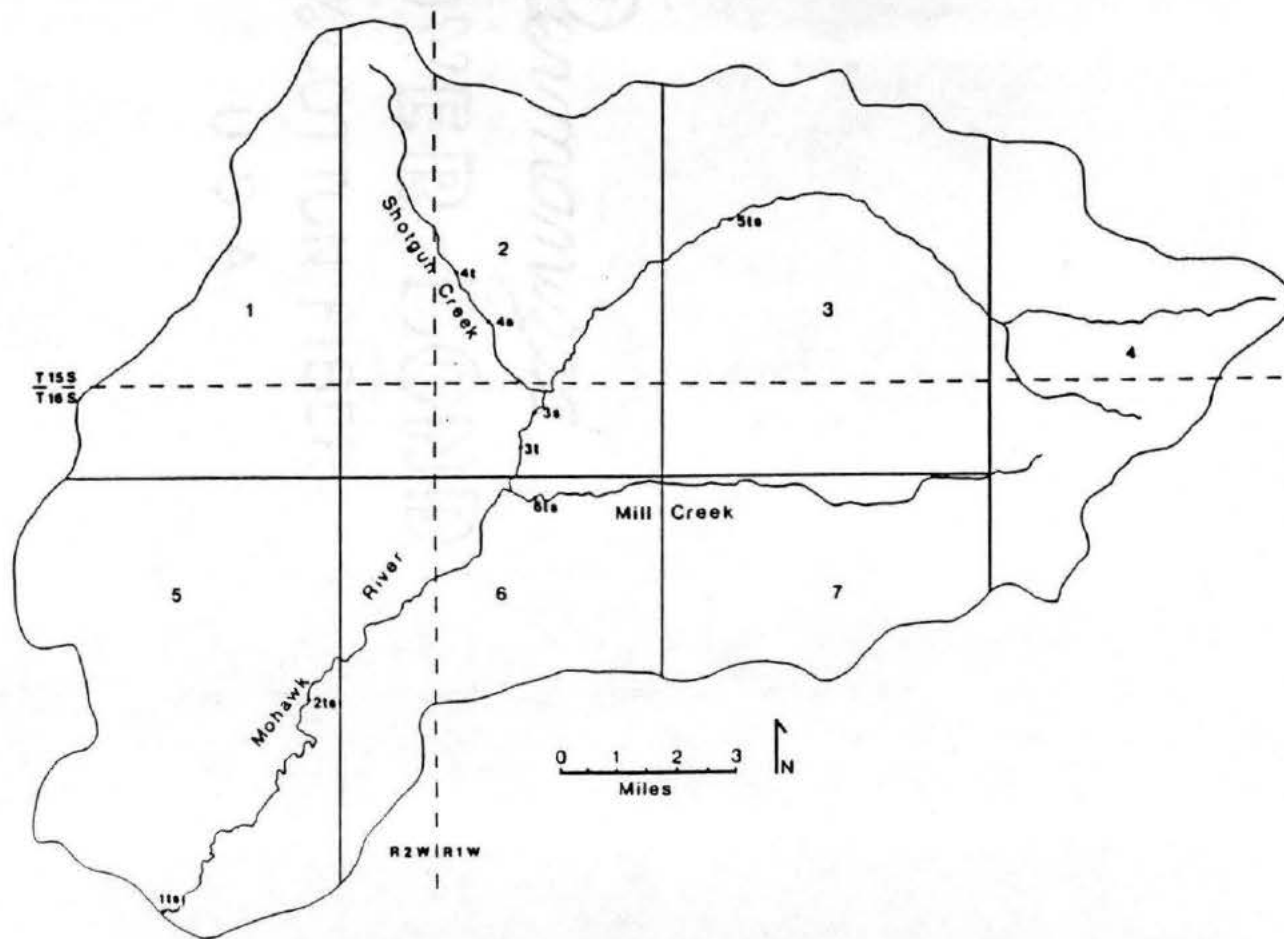
Station Placement

Placement of stations for measuring water temperature and sampling suspended sediment was determined by the proximity of the river and streams to roads and bridges, and by the spatial relationship between monitored tributaries and the main stem of the river. Bridge access is important for taking water samples and measuring velocity during periods of high flow when wading is dangerous or impossible.

A map of the basin and the location of each sampling site can be seen in Figure 16. Maximum-Minimum (Max-Min) thermometers were placed at their respective sites the first

FIGURE 16. Map of station placement in the Mohawk River Basin. The temperature stations are indicated by 't', and the suspended sediment stations are indicated by an 's'.

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of August 1986. Station locations were not the same for both the temperature and suspended sediment studies, except for stations 2 and 6. The temperature stations of 1, 3, 4, and 5 were moved to the nearest bridge when sampling began for suspended sediment in October. Station 1 was moved from the railroad trestle to the bridge 0.16 km (0.1 mi) upstream. Station 3 was moved 1.13 km (0.7 mi) upstream to the second closest bridge because the nearest was covered. Station 4 was moved downstream 1.6 km (1 mi) into the Shotgun Recreation Site where the BLM is currently monitoring the stream for suspended sediment. Station 5 was moved upstream roughly 0.32 km (0.2 mi). The drainage area, main channel length, and percent land use values entered into the analysis have been adjusted for stations 3 and 4 where the change is significant. In summary, station placement remained constant within the separate temperature and suspended sediment studies, but station placement differed between the studies.

Temperature Measurement

Collection of temperature data began August 1, 1986 and continued through September 22, 1986. Thermometers were placed at stations 2 through 6, and a thermograph was placed at station 1. Approximately once per week, temperatures were recorded for the upper five stations. Maximum and minimum temperatures for the preceding period were read off the

Max-Min thermometers. At the time of measuring, the current temperature was read off the max-min thermometer while a simultaneous reading was obtained from a more accurate standard thermometer. Max-min temperatures were adjusted by comparing readings of the standard thermometer, which is accurate to within 1° F, to the current max-min temperature readings. The thermograph at station 1 recorded water temperature continuously throughout this period. The thermograph was checked weekly, and the standard temperature at that location was recorded directly onto the tape. Temperatures were later converted from Fahrenheit to Celsius.

Placement of the thermometers and the thermograph within the stream depended on several site characteristics. Locations were selected to be in flowing water not in pools, and in areas of the stream that did not receive direct midday sun but were shaded the majority of the day. And finally, the locations were selected to be out of view.

Suspended Sediment Collection

Collection of water samples and velocity data began in October of 1986 and continued through March of 1987. In the fall, before rains produced high winter flow, I took water samples and velocity measurements as I waded across the river. Once the river level began to rise, samples and measurements were taken from the bridges using a truck

mounted with boom and winch. Grab samples of water were taken from each station every trip into the field. These samples were taken where the current appeared most rapid.

Integrated water samples and velocity measurements were taken together at selected stations. The depth-integrated samples were taken at specific intervals across the river, sampling the depth of the water column. The depth-integrated sampler allows a specific quantity of water through the orifice depending on the velocity of flow. Flow was determined by measuring velocity at specific intervals across the stream and at depths representative of .6 of the total depth for relatively shallow water and at depths of .2 and .8 of the total depth in deeper water in order to represent average flow.

Statistical Methods

Linear regression analysis was used to analyze both the temperature and suspended sediment data (Montgomery and Peck, 1982). In order to determine the relationship between the measured dependent variables of temperature and suspended sediment and the independent variables that describe the land use within the basin, a hierarchy of basic predictive models was developed. In the analysis of water temperature, this basic model separately employs each of the watershed characteristics as the independent variable for the simple

regression equation. In the analysis of suspended sediment concentration, water discharge was used as the independent variable for the basic model. Then the independent land use variables were added to the basic equation to see whether or not they improved the goodness-of-fit of the regression. A typical multiple regression equation is:

$$y = b_0 + b_1x_1 + b_2x_2 + b_3x_3 + e$$

where,

y = dependent variable

water temperature

suspended sediment

b_0 = intercept of the regression plane

b_1 = expected change in y per unit change in

x_1 when x_2 and x_3 are held constant

b_2 = expected change in y per unit change in

x_2 when x_1 and x_3 are held constant

b_3 = expected change in y per unit change in

x_3 when x_1 and x_2 are held constant

x_1 = basic independent variable

main channel length

drainage area

drainage density

channel slope

discharge

x_2 = independent variable, land use

% forest

% cut

% non-forest

x_3 = independent variable, land use

e = error

Improvement to a regression model, as predictors were added, was determined by comparing the adjusted R^2 values, standard errors of the estimate, regression mean squares, F-tests, and regression coefficients. Adjusted R^2 was used because the addition of regressors to the model does not cause the adjusted R^2 to automatically increase as is true for the ordinary R^2 (Montgomery & Peck, 1982). High values for the adjusted R^2 and F-statistic, and low values for the regression mean square and the standard error, are necessary for model improvement.

The mean square (MS) represents an estimate of the variance from the predicted linear equation (Witte, 1985), and is equal to the sum of squared deviations about their mean, divided by the degrees of freedom. Thus, the smaller the MS value the better the fit is to the predictive model.

The significance of a regression can further be explored through the F-test (Draper & Smith, 1981). The F-test is a test of the hypothesis that an independent variable, such as land use has no effect on a dependent variable, such as stream temperature or suspended sediment concentration. The ratio of the mean square of the regression to the mean square of the residual variation equals F. This calculated F-statistic is then compared to the critical F value. This hypothesis is rejected when the calculated F exceeds the critical F.

Probability is the frequency at which a particular outcome of an event will occur given the total number of possible outcomes (Hamburg, 1983; Walpole, 1982). Probability is expressed by numbers between zero and 1, with 1 signifying that the event is certain to occur and zero signifying that it is impossible for the event to occur. Note that, within my statistical analysis, probability (P) is presented in the form of $1-P$, and thus low values of less than .1000 (a 90% probability of occurrence) bespeaks the significance of effect.

Regression coefficients (b_1) represent the "expected change in x_1 when x_2 is held constant" (Montgomery & Peck, 1982). The significance of the regression coefficients can be quantitatively described through bse, the standard error of beta, and the t-value for a test of the hypothesis that

$b = 0$. In some regression equations, b values are negative. Negative signs indicate an inverse relationship between the dependent variable and the independent variable. For example, in Table 8 of the temperature analysis, the first column reveals that the dependent variable, water temperature, has an inverse relationship to the independent variable, % forest, ($b = -.251$). This relationship indicates that as the percent of forest cover decreases, water temperature increases, or that as the percent of forest cover increases, water temperature decreases. The same column illustrates the opposite relationship with drainage area. Because drainage area has a positive beta value of $b = .01$, drainage area has a direct relationship to water temperature. Thus, as the drainage area increases, water temperature increases, or as drainage area decreases water temperature decreases. The sign of a multiple regression coefficient may also indicate a relationship that appears to be in conflict with intuition or theory, but in actuality is still reliable. This may happen when one regression coefficient changes more rapidly relative to another regression coefficient within that same equation.

Mallows' C_p was then used to compare subsets (two- and three-predictor models) of the full regression models. Subset models may have the drawback that biased predictions or fitted values may be produced. But if they are associated with reduced variance, then the bias may be tolerable

(Weisberg, 1980). Mallows' C_p is "related to the mean square error of a fitted value" (Montgomery & Peck, 1982). In general, small C_p values indicate models with the strongest correlation. In the case of the temperature analysis, the full model is composed of one dependent variable and four independent variables. From the full model, all the possible subset variations of one, two, and three independent variables were compared using Mallows' C_p . In the temperature analysis, three full models were developed in working with Mallows' C_p , because the land use characteristics together represent 100% of the basin land use. Regression analysis requires that variables used within the equations are not linearly related, as they would be if they sum to 100% for all observations. Thus, only two of the three land use characteristics may appear in an equation at one time. So, in order to consider all the possibilities, three "full" models were examined. The equation for Mallows' C_p is as follows (Weisberg, 1980)

$$C_p = (RSS_p / s^2) + 2p - n$$

RSS_p = Residual Sum of Squares from a model
with p parameters

s^2 = residual variance of full model

p = number of parameters in the subset
model (number of predictor variables + 1)

n = number of observations.

CHAPTER V

TEMPERATURE ANALYSIS

This chapter begins by discussing the relationship between water temperature and the location of temperature stations within the drainage basin network. The locations of thermometer placement are shown in Figure 16. Water temperature is discussed in terms of aspect, position within drainage hierarchy, and percent land use above the station. The second section of the chapter presents and discusses the findings from the regression analysis. Data used in the Mohawk Basin temperature analysis is presented in Appendix A.

Spatial Variations in Water Temperature

Water temperatures progressively increase downstream under natural conditions in response to the greater surface area exposed to solar radiation as the river widens. Water temperatures can further elevate as a result of land useage. The maximum temperature of 25° C (77° F) was reached at both stations 1 and 6. Station 1, on the Mohawk River, has the greatest discharge of all the stations in the basin and is expected to have the highest temperatures. Station 6 on Mill

Creek, on the other hand, monitors a tributary of the Mohawk River and is expected to have slightly cooler water temperatures than the main stem. Temperatures on Mill Creek range from 17.8 to 25° C (64 to 77° F). Explanations for these higher than expected water temperatures may be found in (a) the westerly aspect of the sub-basin which receives the more intense afternoon sun, (b) the fact that this creek drains predominantly private land of which 17% has been recently cut-over, while another 1.3% of the area drains non-forest land, and (c) that the stream flows over a channel bottom of bedrock which stores up heat energy for later release.

Water temperatures were coolest on Shotgun Creek (station 4). Weekly maximum temperatures ranged from 15 to 18.3° C (59 to 65° F). Shotgun Creek is a southeasterly flowing stream draining a checkerboard of public (BLM) and private lands. Roughly 6% of the sub-basin above station 4 has been recently cut-over. The sub-basins of Shotgun Creek and Mill Creek show temperatures differing as much as 7° C within the same sampling period (see Figure 17, August 22). The difference in water temperature between Shotgun Creek and Mill Creek may be in response to the difference in sub-basin aspect, the percent of cut-over land, the bedrock channel bottom on Mill Creek, the drainage area monitored, or a combination of all four characteristics. The drainage area above station 4 on Shotgun Creek is 34.99 km², and the

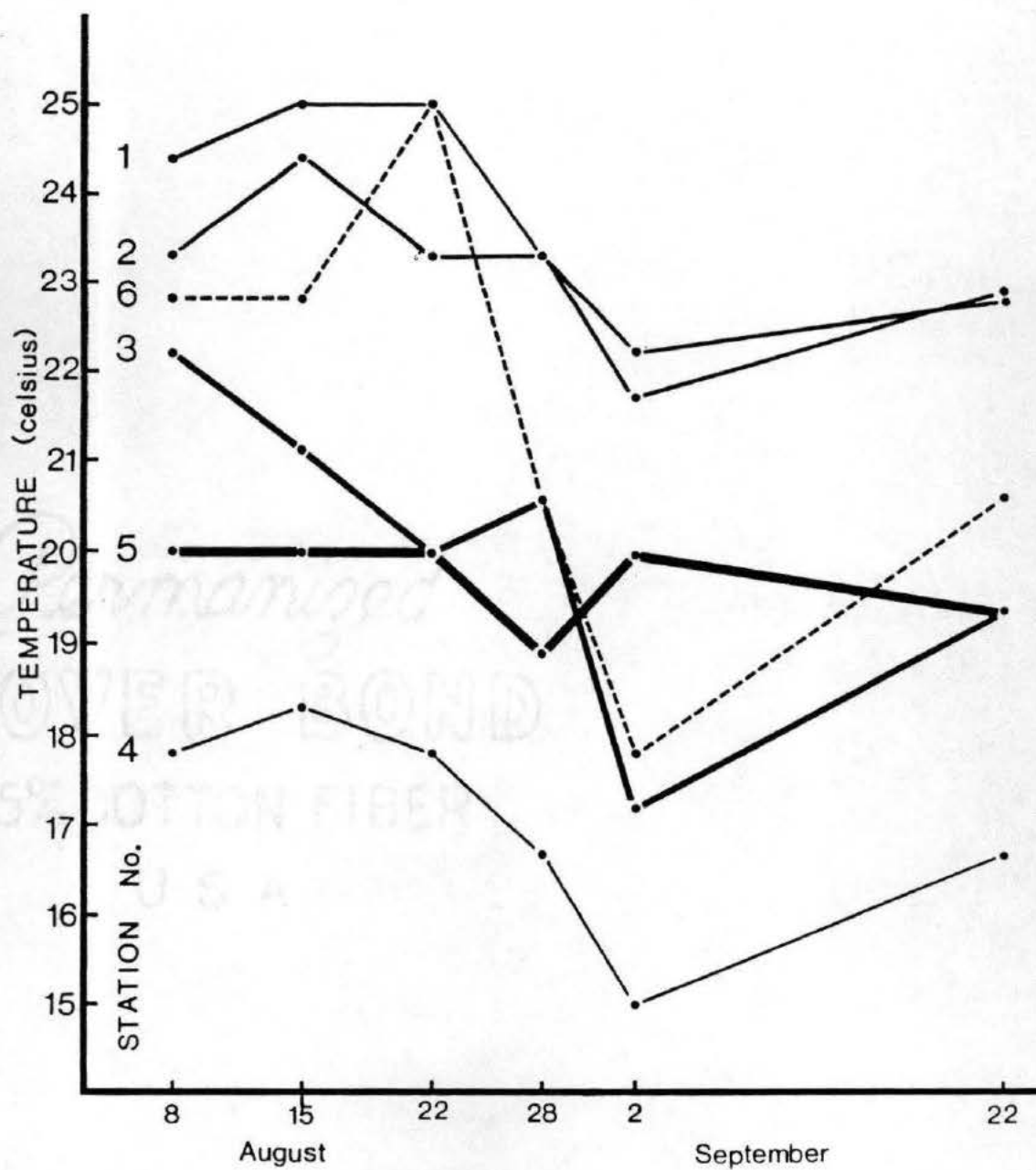


FIGURE 17. Temperature of each station through the sampling period (August 1986 through September 1986).

drainage area above station 6 on Mill Creek is 83.4 km^2 . A larger drainage area allows more time for the solar heating of water to occur.

Stations 2, 3, and 5 produced water temperatures in the mid-range between the highest temperatures at stations 1 and 6 and the coolest temperatures at station 4. The headwaters of the Mohawk River flow northwesterly and westerly and were monitored at station 5. The sub-basin drainage area is 89.22 km^2 , of which 6.65% has been recently cut. Nearly all of the land is privately owned. Water temperatures range from 18.9 to 20° C (66 to 68° F).

Figure 17 shows the temperature variation of each station through the sampling period. Water temperatures throughout the basin were warmest during mid-August. Temperatures cooled slightly during the first part of September and began warming again during the latter half of September. Shotgun Creek has a cooling influence on the water flowing down the Mohawk River from station 5. Water entering the Mohawk River from Mill Creek is equal to or warmer than temperatures monitored up river at station 3. Temperatures at stations 2 and 1 range from 21.7 to 25° C (71 to 77° F).

Regression Analysis

The goal here is to determine whether or not land use

(% cut, % forest, or % non-forest) has an effect on stream temperature, and if so, what the relationship is. The null hypothesis is that land use has no effect on stream temperature. If this hypothesis is true, then the basic regression model will not be improved by the addition of one or more of the land use variables (predictors). If the hypothesis is false, then the regression model will be improved upon by the addition of one or more of the land use variables. A basic regression model with the best single predictor of basin character is desired for the purpose of taking into account the spatial relationship between the different land uses within the watershed.

The watershed characteristics used as independent variables include drainage area, main channel length, slope, and drainage density. Regression analysis on the weekly maximum temperatures show that the best basic single predictor correlating with the actual measured temperatures, is main channel length (see Table 6).

Evaluation of the three full models using Mallows' C_p also revealed that main channel length, with the lowest C_p value, is the best single predictor variable (see Table 7). Drainage area is the next best single predictor. Figure 18 shows the graphic relationships between water temperature and both main channel length and drainage area. These graphs indicate that as main channel length increases water temperature increases, and that as drainage area increases

Table 6

Basic Single-Predictor Regression Model

Independent variable (IV)		Predictor used			
Drainage area (DA) [km ²]	X				
Main channel length (MC) [km]		X			
Channel slope (CS)			X		
Drainage density (DD) [km/km ²]				X	
R ²	.531	.595	.36	.053	
Standard error (se)	1.851	1.72	2.163	2.632	
Mean square (MS)	132.123	148.061	89.636	13.095	
F test (F)	38.548	50.042	19.165	1.89	
1 - Probability (1-P)	.0001	.0001	.0001	.1782	

Note. Regression calculations from metric units.

water temperature also increases.

Main channel length and drainage area separately provide the best basic regression models, so these two variables were allowed to remain in the analysis. Channel slope and drainage density were dropped from further analysis. Land use predictors were then added to the basic models in varying combinations. The improvement of these basic models can be seen in Table 8. Main channel length and either % forest or % cut provide a better fit to the measured water temperatures, as compared to drainage area and either % forest or % cut. The best two-predictor model is main channel length and % cut, followed in order by main channel

Table 7

Analysis of Mallows' Cp for Single-Predictor Models

(1) Full Model: Main channel length, drainage area, % cut, % forest. Variance = 1.879

IV	RSSp	p	n	2p-n	Cp
MC	100.597	1	36	-34	19.538
DA	116.536	1	36	-34	28.020
% Forest (%F)	156.794	1	36	-34	49.445
% Cut (%C)	237.932	1	36	-34	92.627

(2) Full Model: Main channel length, drainage area, % forest, % non-forest. Variance = 1.884

IV	RSSp	p	n	2p-n	Cp
MC	100.597	1	36	-34	19.396
% Non-forest (%NF)	107.889	1	36	-34	23.266
DA	116.536	1	36	-34	27.856
%F	156.794	1	36	-34	49.224

(3) Full Model: Main channel length, drainage area, % cut, % non-forest. Variance = 1.883

IV	RSSp	p	n	2p-n	Cp
MC	100.577	1	36	-34	19.424
%N F	107.889	1	36	-34	23.296
DA	116.536	1	36	-34	27.888
%C	237.932	1	36	-34	92.358

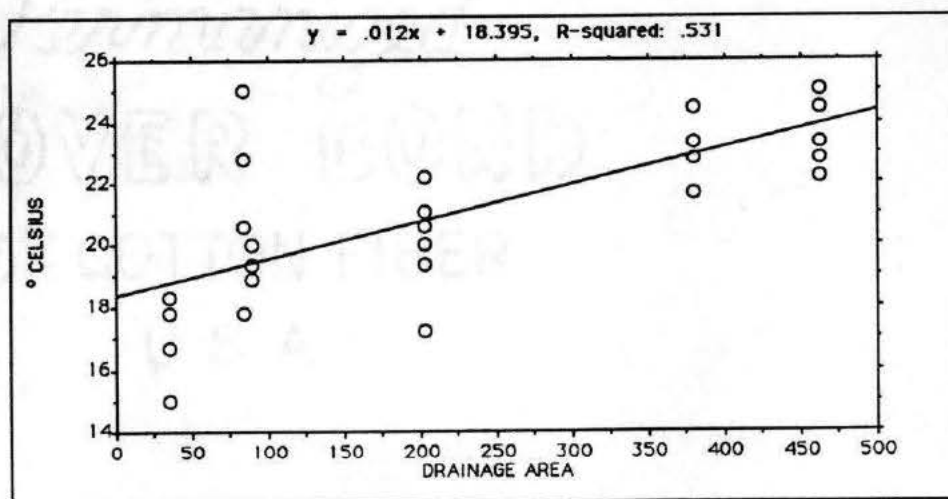
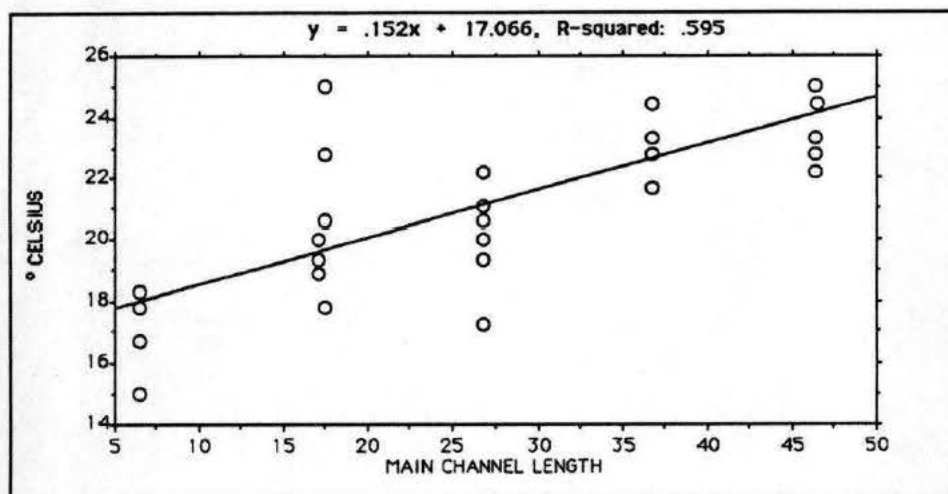


FIGURE 18. Graphic representation of the relationship between water temperatures and both main channel length and drainage area.

Table 8

Comparison of Two-Predictor Regression Models

IV	Predictors used					
DA	X	X	X			
MC			X	X	X	
%F	X			X		
%NF	X			X		
%C			X			X
R ²	.671	.544	.683	.692	.572	.699
se	1.529	1.8	1.5	1.478	1.744	1.462
MS	85.756	70.884	87.215	88.268	74.154	89.057
F	36.683	21.884	38.773	40.388	24.385	41.659
1-P	.0001	.0001	.0001	.0001	.0001	.0001
b ₀	41.143	19.189	15.62	37.227	17.32	14.785
	<u>DA</u>	<u>DA</u>	<u>DA</u>	<u>MC</u>	<u>MC</u>	<u>MC</u>
b	.01	-.006	.014	.125	.13	.165
bse	.002	.01	.002	.02	.082	.019
bsv	.596	-.354	.841	.632	.657	.833
bt	5.837	.555	8.531	6.224	1.575	8.849
bP	.001	.5826	.0001	.0001	.1249	.0001
	<u>%F</u>	<u>%NF</u>	<u>%C</u>	<u>%F</u>	<u>%NF</u>	<u>%C</u>
b	-.251	1.166	.282	-.219	.126	.233
bse	.061	.676	.065	.061	.442	.062
bsv	-.419	1.101	.427	-.366	.119	.353
bt	4.105	1.726	4.337	3.61	.285	3.749
bp	.0002	.0938	.0001	.001	.7774	.0007

Note. Regression calculations from metric units.

length and % forest, drainage area and % cut, and drainage area and % forest. The models of main channel length and % non-forest, and drainage area and % non-forest either had relatively large beta standard error values, t values close to zero, or unacceptable beta probabilities. Similarly, Mallows' Cp showed main channel length and % cut as the best two-predictor temperature model, and main channel length and % forest as the next best model (see Table 9).

An interesting change occurred once the three-predictor models were tested. Drainage area became the most significant predictor as opposed to main channel length. Regression coefficients in the three predictor main channel/land use models each have unacceptably high standard errors, t statistics close to zero, and low probability values. Drainage area in combination with any two of the land use variables produces an equally good fit to the measured water temperatures (see Tables 10 and 11). The values of Mallows' Cp are little different for the three-predictor models, and apparently the three different combinations of drainage area, % cut, and % forest; drainage area, % forest and % non-forest; and drainage area, % cut, and % non-forest all predict water temperatures equally well (see Table 12).

Comparison of Mallows' Cp between the one-, two-, and three-predictor models reveals that the best models are the three-predictor models with drainage area (Table 12), and the

Table 9

Analysis of Mallows' Cp for Two-Predictor Models

(1) Full Model: Main channel length, drainage area, % cut, % forest. Variance = 1.879

IV	RSSp	p	n	2p-n	Cp
MC, %C	70.545	2	36	-32	5.544
MC, %F	72.122	2	36	-32	6.383
DA, %C	74.23	2	36	-32	7.505
DA, %F	77.146	2	36	-32	9.057

(2) Full Model: Main channel length, drainage area, % forest, % non-forest. Variance = 1.884

IV	RSSp	p	n	2p-n	Cp
MC, %F	72.122	2	36	-32	6.281
DA, %F	77.146	2	36	-32	8.948
MC, %NF	100.35	2	36	-32	21.264
DA, %NF	106.891	2	36	-32	24.736

(3) Full Model: Main channel length, drainage area, % cut, % non-forest. Variance = 1.883.

IV	RSSp	p	n	2p-n	Cp
MC, %C	70.545	2	36	-32	5.464
DA, %C	74.23	2	36	-32	7.421
MC, %NF	100.35	2	36	-32	21.293
DA, %NF	106.891	2	36	-32	24.766

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Table 10

Comparison of Three-Predictor Regression Models

IV	Predictors used					
DA	X	X	X			
MC				X	X	X
%F	X	X		X	X	
%NF	X		X	X		X
%C		X	X		X	X
R ²	.71	.711	.71	.69	.691	.69
se	1.436	1.434	1.435	1.484	1.483	1.483
MS	60.894	60.965	60.91	59.405	59.438	59.428
F	29.536	29.665	29.564	26.985	27.039	27.022
P	.0001	.0001	.0001	.0001	.0001	.0001

two-predictor model with main channel length and % cut (Table 9). The smallest Cp value produced by any of the subset models was 4.999 for the drainage area, % cut, and % forest regression model.

Within the three-predictor regression analysis, the drainage area models produced higher adjusted R² values (.71) than did the main channel models (.69) (Table 10). Comparing the three-predictor drainage area models, the standard error, mean square, F-test and probability values are nearly the same. Similarly, comparing the three-predictor main channel length models, the standard error, mean square, F-test and probability values are nearly the same. The t-statistics for

Table 11

Regression Coefficients for Models with Three-Predictor
Variables

IV		Predictors used				
DA	X	X	X			
MC				X	X	X
%F	X	X		X	X	
%NF	X		X	X		X
%C		X	X		X	X
b ₀	56.324	-146.856	13.026	38.199	3.229	14.543
	<u>DA</u>	<u>DA</u>	<u>DA</u>	<u>MC</u>	<u>MC</u>	<u>MC</u>
b	.041	.039	.04	.185	.185	.184
bse	.013	.013	.013	.072	.07	.072
bsv	2.479	2.374	2.455	.936	.936	.93
bt	3.044	3.118	3.032	2.578	2.647	2.567
bp	.0046	.0038	.0048	.0147	.0125	.0151
	<u>%F</u>	<u>%F</u>	<u>%NF</u>	<u>%F</u>	<u>%F</u>	<u>%NF</u>
b	-.434	1.601	-1.676	-.237	.113	-1.06
bse	.097	.789	.835	.064	.374	.381
bsv	-.726	2.681	-1.581	-.397	.189	-.1
bt	4.455	2.03	2.007	3.686	.302	.278
bp	.0001	.0508	.0532	.0008	.7643	.7829
	<u>%NF</u>	<u>%C</u>	<u>%C</u>	<u>%NF</u>	<u>%C</u>	<u>%C</u>
b	-2.132	2.014	.429	-.347	.348	.236
bse	.916	.856	.096	.397	.387	.064
bsv	-2.012	3.056	.651	-.328	.528	.357
bt	2.328	2.353	4.459	.873	.899	3.692
bp	.0264	.0249	.0001	.3891	.3752	.0008

Table 12

Analysis of Mallows' Cp for Three-Predictor Models

(1) Full Model: Main channel length, drainage area, % cut, % forest. Variance = 1.879

IV	RSSp	p	n	2p-n	Cp
DA, %C, %F	65.763	3	36	-30	4.999
MC, %C, %F	70.344	3	36	-30	7.437

(2) Full Model: Main channel length, drainage area, % forest, % non-forest. Variance = 1.884

IV	RSSp	p	n	2p-n	Cp
DA, %F, %NF	65.975	3	36	-30	5.019
MC, %F, %NF	70.444	3	36	-30	7.391

(3) Full Model: Main channel length, drainage area, % Cut, % non-forest. Variance = 1.883

IV	RSSp	p	n	2p-n	Cp
DA, %C, %NF	65.929	3	36	-30	5.013
MC, %C, %NF	70.375	3	36	-30	7.374

the test of the hypothesis that the regression coefficients are equal to zero, for the three-predictor main channel models, are unacceptably high, that is the t-tests show that the coefficients are not significantly different from zero.

T-tests for the three-predictor drainage area models show that these regression coefficients are significantly different from zero. For this reason any of the three-predictor drainage area models would provide a good regression equation for predicting stream temperature.

As seen in the previous pages, the addition of land use variables improved the basic regression equation. Thus, the null hypothesis stating that land use has no effect on stream temperature is rejected. High values of the F-statistics also support this conclusion. In order for the null hypothesis to be true, low F values are necessary. Tables 8 and 10 show that the F values are high and vary from 21.884 to 41.659.

Temperatures Predicted from Models

An example of a three-predictor regression equation with drainage area, % forest, and % cut as predictors is:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_3x_3$$

$$Y = \text{stream temperature} = T$$

$$T_1 = \text{temperature at station 1}$$

$$T_1 = \text{intercept} + b_1(\text{DA}) + b_2(\%F) + b_3(\%C)$$

$$T_1 = -146.856 + (0.039)(462.21) + (1.601)(86.6) + (2.014)(6.82)$$

$$T_1 = 23.5^\circ \text{ C } (74^\circ \text{ F})$$

Table 13 provides a comprehensive view of the predicted water temperatures for each station along the Mohawk River using the regression coefficients derived for the three drainage area regression models, and the specific basin characteristics and land use values for each station. Predicted temperatures from the drainage area models show little or no difference between the basic model of drainage area alone or the three-predictor drainage area models for stations 1 and 3. Station 2, however, shows that land use in that area (non-forest), or land use above station 2 (for example the Mill Creek sub-drainage), is causing an increase in the predicted water temperature of 1° F over the water temperature predicted by the basic model. The predicted temperatures for station 4, Shotgun Creek, show that land use practices there (forest and cut-over land, public (BLM) and private ownership) are providing stream shade which is having a cooling effect of 3° F on stream temperature relative to the predicted basic model temperatures. Station 5 shows no difference between the basic model and three-predictor models. Station 6, Mill Creek, shows that land use (forest and cut-over land, private ownership) is causing an increase in stream temperatures of 4° F over the basic model predicted temperatures.

Table 14 is a presentation of the main channel length predicted temperatures. Predicted temperatures for stations 1 and 2 show no difference between the basic model and the

Table 13

Maximum Temperatures Predicted by Drainage Area/Land Use
Regression Models

STATION	°C (°F)							
	REGRESSION MODEL							
	*	**						
	DA	DA	%F %C		DA	%F %NF	DA	%NF %C
X1	23.9 (75)		23.5 (74)		23.7 (75)		23.4 (74)	
X2	22.9 (73)		23.3 (74)		23.4 (74)		23.2 (74)	
X3	20.8 (69)		20.4 (69)		20.4 (69)		20.3 (69)	
X4	18.8 (66)		17.0 (63)		17.0 (63)		17.0 (63)	
X5	19.5 (67)		19.5 (67)		19.5 (67)		19.4 (67)	
X6	19.4 (67)		21.6 (71)		21.6 (71)		21.6 (71)	

* Basic model

** Best three-predictor model

two-predictor models and thus indicates that land use is not significantly changing water temperatures. Predicted temperatures from the two-predictor land use models at stations 3, 4, and 5, show that land use practices present act as a buffering influence to the stream environment to the order of 1 to 2° F lower than the basic model predicts for these stations. Predictive models for station 6, Mill Creek, indicate that land use practices there are elevating the temperatures as much as 4° F above the predicted basic model

Table 14

Maximum Temperatures Predicted by Main Channel Length/Land
Use Regression Models

STATION	°C (°F)		
	REGRESSION MODEL		
	* MC	** MC %C	MC %F
X1	24.1 (75)	24.0 (75)	24.0 (75)
X2	22.96 (73)	22.7 (73)	22.7 (73)
X3	21.1 (70)	20.7 (69)	20.6 (69)
X4	18.1 (65)	17.3 (63)	17.5 (63)
X5	19.7 (67)	19.1 (66)	18.9 (66)
X6	19.7 (67)	21.7 (71)	21.6 (71)

* Basic model

** Best two-predictor model

temperature.

Simple Graphic Relationships Between Land Use
and Water Temperature

The direct relationships between the dependent water temperature variable and the independent land use variables are shown in graphic form in figure 19. The first graph indicates that as the percent of non-forest land and cut-over

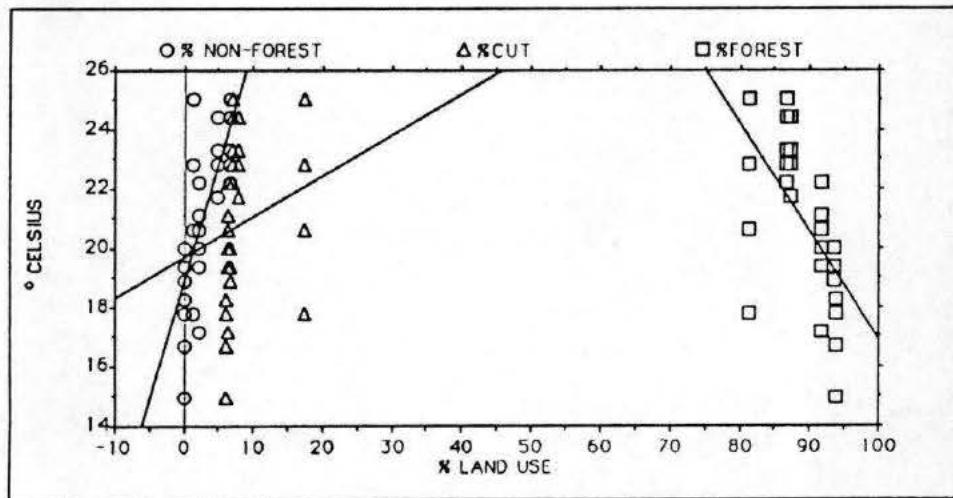


FIGURE 19. A comparison between water temperature and the land uses of % non-forest, % cut, and % forest.

land increase, water temperatures also increases. The second graph shows that as the percent of forest land increases water temperature decreases. Simple regression equations for maximum water temperature for each land use variable are:

% Non-forest	$Y = .797x + 18.899,$	$R^2 = .566$
% Cut	$Y = .137x + 19.732,$	$R^2 = .043$
% Forest	$Y = -.363x + 53.199,$	$R^2 = .369$

Summary

The best regression model for predicting water temperature includes drainage area, % cut, and % forest as predictors. The two-predictor main channel length and % cut equation is also a good model for predicting water temperature. Water temperatures are shown to increase with increasing drainage area or main channel length. Both non-forest and cut-over land have a positive relationship to water temperature, in that as % non-forest or % cut-over land increases water temperature increases. Forest land was found to have a negative or inverse relationship to water temperature, in that as the % forest land increases water temperature decreases. Land use was found to be most influential on water temperature at station 4 on Shotgun Creek and at station 6 on Mill Creek. Land use within the Shotgun Creek sub-drainage was shown to have a cooling

influence on water temperature, whereas land use within the Mill Creek sub-drainage was shown to have a heating influence on water temperature.

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CHAPTER VI

SUSPENDED SEDIMENT ANALYSIS

The null hypothesis for the suspended sediment analysis is that land use has no effect on suspended sediment concentration. This chapter begins with a discussion on how discharge was estimated for the grab sediment samples taken at each station. Once discharge was determined, regression analysis was run on the suspended sediment and discharge variables for the entire data set. Next the entire data set was divided into fall and winter subsets to determine if there is any seasonal relationship between suspended sediment and discharge. Land use and soil type were separately added into the regression equations. The best predictive models were then determined, and discussion of them and their significance is presented in the summary. The suspended sediment and discharge data used in this chapter can be found in Appendix B.

Discharge Data

A USGS gaging station at station 1 measures stream discharge for the Mohawk River continuously. However,

because discharge at stations above station 1 were determined only on those occasions when integrated water samples were taken, discharge had to be estimated for the times at which the grab samples were taken. Each station has a minimum sample number of three discharge values from which simple predictive equations for discharge were developed. Discharge at each station was estimated using a regression model that related discharge at the station to the simultaneous USGS discharge values of station 1 (see Figure 20).

Models with Entire Data Set

Analysis of the sediment data began with regression equations developed from the entire data set spanning the October through March time period of water year 1987 (see Appendix B). These models all produced R^2 and adjusted R^2 values below .1 (see Table 15). Standard error values of the beta coefficients (bse) for the land uses are all larger than the beta value (b). Furthermore, all the probability values of the beta coefficients (bp) for the land uses are unacceptably low. It thus appeared that the data set was heterogeneous.

Seasonal Models

The data set was then split into fall and winter subsets,

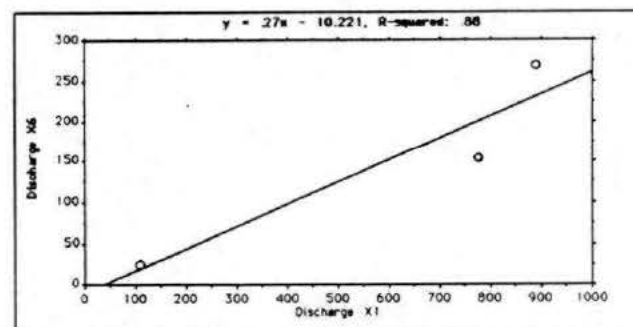
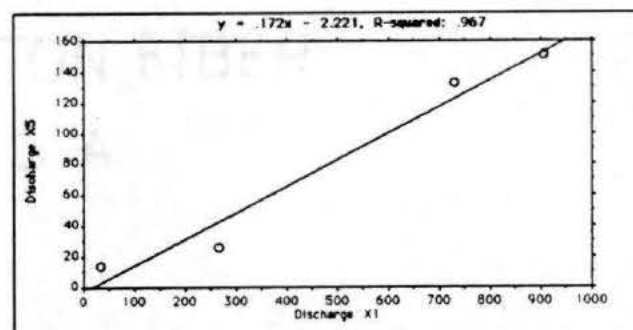
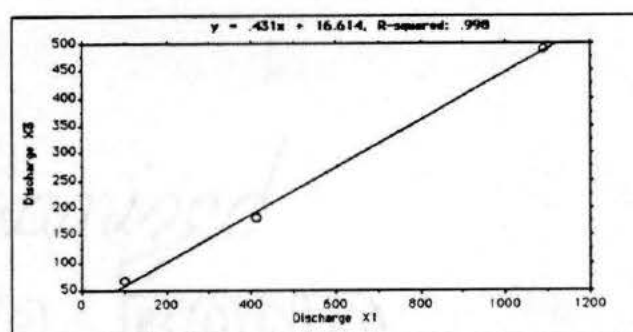
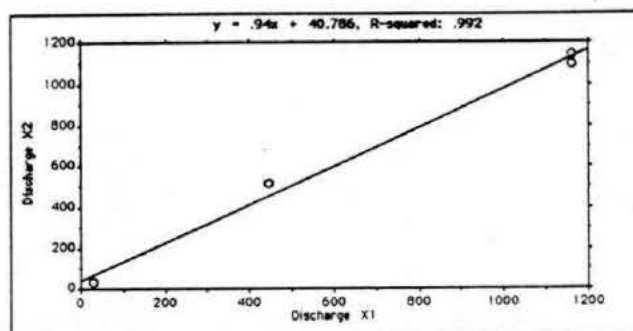


FIGURE 20. Simple regression models used to predict discharge for stations 2, 3, 5, and 6.

Table 15

Entire Data Set: Basic and Land Use Regression Models

IV	Predictors used			
Q station	X	X	X	X
% forest		X		
% cut			X	
% non-forest				X
R^2	.073	.072	.073	.067
se	7.465	7.468	7.466	7.487
MS	454.702	253.016	254.223	240.226
F	8.16	4.537	4.56	4.285
(1-P)	.0053	.033	.013	.0167
b_0		-7.143	9.537	7.234
		<u>Qst</u>	<u>Qst</u>	<u>Qst</u>
b		.006	.005	.005
bse		.002	.002	.002
bsv		.314	.267	.244
bt		3.006	2.582	2.027
bp		.0034	.0115	.0457
		<u>%F</u>	<u>%C</u>	<u>%NF</u>
b		.168	-.195	.259
bse		.175	.199	.382
bsv		.1	-.101	.082
bt		.959	.982	.678
bp		.34	.3288	.4997

on the premise that the first several storm events of the season flush the watershed of sediment that has been accumulating on the hillslopes and stream channels during the dry summer season. If this premise is true, higher sediment concentrations for a given discharge are produced in the fall and lower sediment concentrations for the same discharge in the winter and spring. The hydrograph of the Mohawk River discharge, with suspended sediment concentrations, supports this premise (see Figure 21). Thus, storm events in both the fall and winter may be producing streamflow of equal discharge, but lower sediment availability in the winter is the limiting factor controlling the concentration of suspended sediment present.

The fall subset includes data from October through December for all stations, and the winter subset covers the months of January through March for all stations. Adjusted R^2 and R^2 values improved with the fall subset to around .4 for all models (see Table 16), whereas the R^2 values of the winter subset remained below .1 indicating no relationship (see Table 17). One reason for a lack of correlation within the entire data set and within the winter subset may be that the data represents only the rainy season of one water year. Data from several years, on the other hand, would provide a more statistically sound background for analysis. Along the same line, there were several storm events during which no water samples were taken (see Figure 21). A more likely

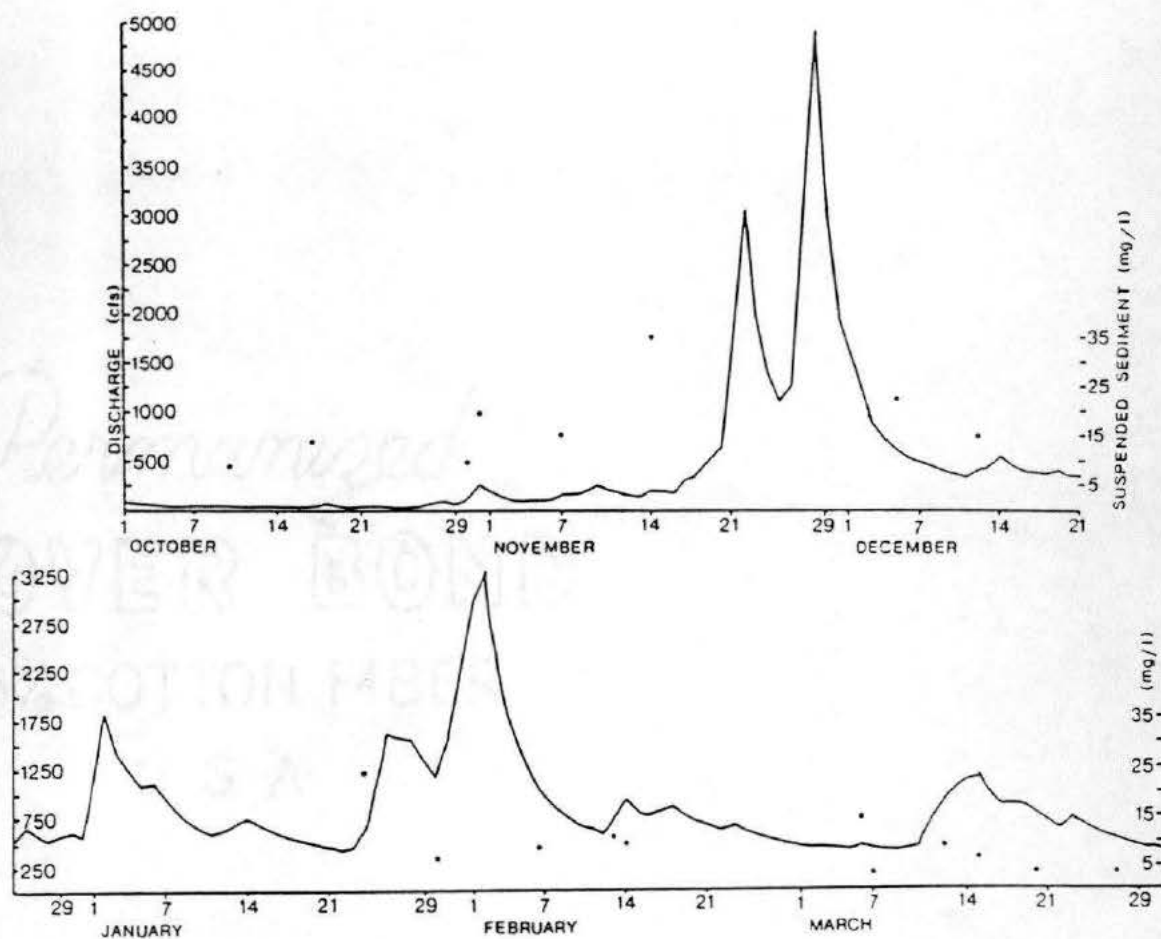


FIGURE 21. Hydrograph of daily mean discharge at station 1 on the Mohawk River (line) with corresponding suspended sediment concentrations (dots).

Table 16

Fall Series, Basic, and Land Use Regression Models

IV	Predictors used			
Q station	X	X	X	X
% forest		X		
% cut			X	
% non-forest				X
R ² or adj R ²	.412	.446	.407	.379
se	6.799	6.51	6.738	6.894
MS	1167.492	674.077	621.318	584.12
F	25.259	15.905	13.687	12.292
(1-P)	.0001	.0001	.0001	.0001
b ₀	-33.3	13.122	10.086	
	<u>Qst</u>	<u>Qst</u>	<u>Qst</u>	
b	.015	.013	.014	
bse	.003	.003	.003	
bsv	.689	.623	.648	
bt	5.537	4.89	4.722	
bp	.0001	.0001	.0001	
	<u>%F</u>	<u>%C</u>	<u>%NF</u>	
b	.493	-.367	-.061	
bse	.239	.285	.487	
bsv	.242	-.164	-.017	
bt	2.065	1.287	.126	
bp	.0464	.2067	.9008	

Table 17

Winter Series, Basic, and Land Use Regression Models

IV	Predictors used			
Q station	X	X	X	X
% forest		X		
% cut			X	
% non-forest				X
R^2	.022	-.017	-.014	.005
se	5.831	5.889	5.881	5.826
MS	39.572	19.788	22.222	38.14
F	1.164	.571	.643	1.124
(1-P)	.2857	.5688	.5302	.3332
b_0		6.471	7.102	6.047
		<u>Qst</u>	<u>Qst</u>	<u>Qst</u>
b		.003	.002	-.001
bse		.003	.003	.004
bsv		.149	.131	-.034
bt		1.005	.88	.152
bp		.3199	.383	.8799
		<u>%F</u>	<u>%C</u>	<u>%NF</u>
b		-.002	-.078	.559
bse		.184	.207	.538
bsv		-.002	-.056	.233
bt		.012	.375	1.04
bp		.9905	.709	.3034

reason for lack of a correlation may hinge upon the fact that the quantity of suspended sediment does not solely depend on discharge, but on the availability of sediment for transport within the basin.

The basic regression model for the fall series, with suspended sediment as the dependent variable and station discharge (Q station) as the independent variable, produced an R^2 value of .412. A scattergram of the relationship between sediment and discharge for the Fall subset (Figure 22) shows that sediment concentration increases with increasing discharge, and that there is a definite relationship between discharge and suspended sediment. This relationship illustrates the fact that the quantity of suspended sediment transported within a stream is dependent on sediment availability, and in this basin, sediment is available in greater quantity during the fall months. Figure 23 shows a scattergram of the relationship between sediment concentration and discharge for the winter and spring months. The lack of correlation between discharge and suspended sediment indicates the lack of sediment availability during the winter and spring months.

Fall Subset Models Containing Land Use Variables

The addition of the land use variables of % cut and % non-forest to the basic fall subset equation did nothing to

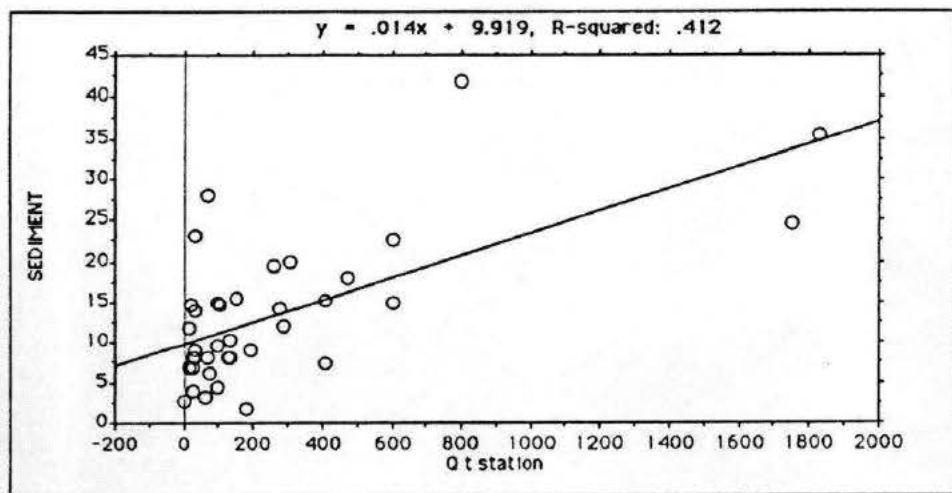


FIGURE 22. Scattergram of sediment vs. discharge, Fall subset, October 1987 to December 1987 (water year).

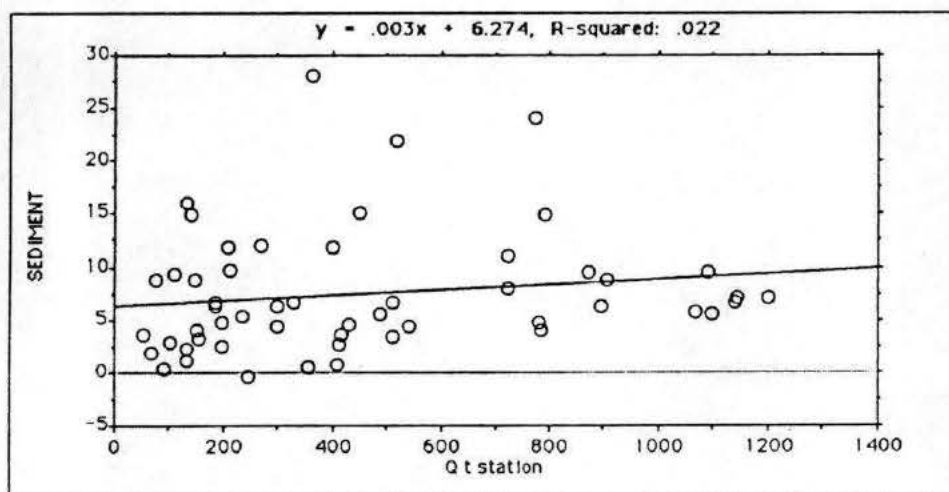


FIGURE 23. Scattergram of sediment vs. discharge, Winter subset, January 1987 to March 1987 (water year).

improve the correlation (see Table 16). The equation of Q station and % forest increased the R^2 to an adjusted R^2 value of .446. The standard error of the beta coefficient (bse) for this equation is half the size of the beta value (b) and thus is marginally acceptable or marginally unacceptable. The relationship between % forest and suspended sediment is positive, meaning that as the percent of forest land increases the quantity of suspended sediment also increases. This is counter-intuitive unless (a) there is some process unaccounted for generating sediment within the forested land (i.e. highly erodible geologic material, or some other unidentified sediment point source), or (b) a spurious correlation may have been generated. The separate addition of both % cut and % non-forest caused a decrease in the adjusted R^2 and F values as compared to the basic model. Standard errors for the % cut and % non-forest beta coefficients (bse) are fairly large relative to their beta values (b), and beta probability (bp) values for both of these land uses are unacceptably low and are cause for the rejection of these models.

Three-predictor models, including discharge and two land use variables, were estimated and found to be inferior models. Adjusted R^2 values were either slightly increased or decreased whereas all the F values decreased. Beta standard error values (bse) were high as compared to the beta values (b) for all the land uses. Beta probability values for

% cut and % non-forest were unacceptably low.

The addition of soil variables to the fall series equation did not improve the basic regression model (see Table 18). Adjusted R^2 values fell to below .4. Standard errors for the soil beta coefficients are all greater than the beta values (b), and probabilities for the soil beta coefficients are all unacceptably low.

The winter series regression models produced R^2 values of less than .1, very low F values, and unacceptably low probabilities (see Table 17). Standard errors for the beta coefficients (bse) are equal to or greater than those of the beta value (b) for all predictors, and probabilities for the beta coefficients are unacceptably low.

The best fall series models are the two-predictor Q station and % forest model, and the single-predictor Q station model. In order to determine the better of these two models, Mallows' Cp was calculated (see Table 19). Mallows' Cp indicates that Q station and % forest is the best model, and Q station alone is the next best model.

A residual plot was constructed to determine whether there was some unapparent relationship between % forest and the residuals of suspended sediment and Q station (see Figure 24). No trends were found, though station 3 (91.3% forest) has greater residual variability.

Table 18

Fall Series: Soils Regression Models

IV		Predictors used				
Qst	X	X	X	X	X	X
Soil 1	X					
Soil 2		X				
Soil 3			X			
Soil 4				X		
Soil 5					X	
Soil 6						X
R ²	.38	.386	.386	.391	.379	.383
se	6.889	6.852	6.852	6.825	6.893	6.871
MS	585.146	594.075	694.075	600.537	584.196	589.531
F	12.329	12.653	12.653	12.892	12.295	12.487
(1-P)	.0001	.0001	.0001	.0001	.0001	.0001
b ₀	10.366	9.589	9.589	11.525	12.368	8.211
	<u>Qst</u>	<u>Qst</u>	<u>Qst</u>	<u>Qst</u>	<u>Qst</u>	<u>Qst</u>
b	.014	.013	.013	.014	.014	.014
bse	.003	.003	.003	.003	.003	.003
bsv	.653	.626	.626	.669	.642	.66
bt	4.752	4.78	4.78	5.063	4.958	4.926
bp	.0001	.0001	.0001	.0001	.0001	.0001
	<u>S1</u>	<u>S2</u>	<u>S3</u>	<u>S4</u>	<u>S5</u>	<u>S6</u>
b	-.109	2.557	3.267	-.137	-.05	.049
bse	.45	3.855	4.926	.161	.362	.1
bsv	-.033	.087	.087	-.112	-.081	.066
bt	.243	.663	.663	.849	.138	.495
bp	.8095	.5115	.5115	.4016	.8914	.6237

Table 19

Analysis of Mallows' Cp for One- and Two-Predictor Models

(1) Full Model: Q station, % forest, and % cut.
Variance = 40.089

<u>IV</u>	<u>RSSp</u>	<u>p</u>	<u>n</u>	<u>2p-n</u>	<u>Cp</u>
Qst, %F	1483.154	2	38	-34	2.996
Qst	1663.982	1	38	-36	5.507
Qst, %C	1588.838	2	38	-34	5.633

(2) Full Model: Q station, % forest, % non-forest.
Variance = 39.398

<u>IV</u>	<u>RSSp</u>	<u>p</u>	<u>n</u>	<u>2p-n</u>	<u>Cp</u>
Qst, %F	1483.154	2	38	-34	3.645
Qst	1663.982	1	38	-36	6.235
Qst, %NF	1663.234	2	38	-34	8.216

(3) Full Model: Q station, % cut, and % non-forest.
Variance = 42.607

<u>IV</u>	<u>RSSp</u>	<u>p</u>	<u>n</u>	<u>2p-n</u>	<u>Cp</u>
Qst	1663.982	1	38	-36	3.054
Qst, %C	1588.838	2	38	-34	3.291
Qst, %NF	1663.234	2	38	-34	5.037

(4) Full Model: Q station, % non-forest, and % woods.
Variance = 41.288.

<u>IV</u>	<u>RSSp</u>	<u>p</u>	<u>n</u>	<u>2p-n</u>	<u>Cp</u>
Qst	1663.982	1	38	-36	4.302
Qst, %W	1609.331	2	38	-34	4.978
Qst, %NF	1663.234	2	38	-34	6.284

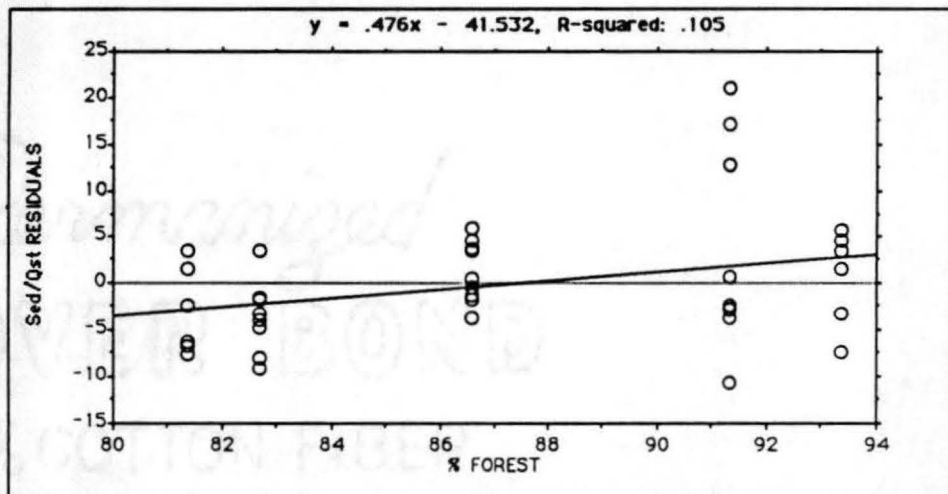


FIGURE 24. Plot of Sediment and Q station residuals versus % forest.

Summary

The best correlation between suspended sediment and stream discharge was found in the fall subset. No apparent correlation was seen for the entire data set or the winter subset between suspended sediment and discharge. This indicates that the concentration of suspended sediment within the stream depends primarily on sediment availability and secondarily on discharge. Thus if there is little or no sediment entering the stream network, there will be little or no suspended sediment being transported regardless of the stream discharge capability to transport sediment.

The Q station, and % forest model for the fall sub-set produced only a marginal correlation and thus the null hypothesis, that land use has no effect on suspended sediment concentration, cannot be proved true or false.

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CHAPTER VII

CONCLUSIONS

This final chapter presents a summary of the findings broken down into water temperature and suspended sediment subsections. Findings were then compared to previous studies. A discussion of the limitations of the study, and then suggestions for further study brings a close to this chapter.

Summary of Results

This study of the Mohawk River basin has two primary objectives; the first, to determine the relationship between water temperature and land use, and the second, to determine the relationship between suspended sediment and land use. I have found that land use within the basin has a significant effect on water temperature. The relationship between suspended sediment and land use within the basin is less clear.

Water Temperature

Water temperature was found to have a positive relationship to both main channel length and drainage area, meaning that water temperature increases downstream. The best regression models for the relationship between water temperature and land use are the three-predictor models that include drainage area and any combination of two land use variables. The best two-predictor regression model includes main channel length and % cut. Non-forest land and cut-over land were found to have a positive relationship to water temperature, that is, as the percent of non-forest or cut-over land increases water temperature also increases. Forest land was found to have a negative or inverse relationship with water temperature, that is, as the percentage of forested land increases water temperatures decrease. The predictive temperature models developed show that the most significant effects of land use on water temperature occurring within the basin are taking place in the sub-drainages of Shotgun Creek and Mill Creek. Shotgun Creek, station 4, shows that water temperature is 3° F cooler there, as a result of land use, than in the predicted base model temperatures. Mill Creek, station 6, on the other hand, shows that the stream is being heated 4° F above the predicted base model's temperature by land use. Seventeen percent of the Mill Creek sub-drainage has been recently

cut-over, whereas only 6 percent of the Shotgun Creek sub-drainage has been recently cut.

As discussed in the literature review, the removal of riparian vegetation within a clearcut allows for greater quantities of solar radiation to reach the stream surface and thus elevate stream temperatures. Brown and Krygier (1970) found that the thermal radiation incident to a stream surface in a clearcut watershed was 10 times greater than that incident to a stream surface in a patch-cut watershed. The Mill Creek sub-drainage is an example of where water temperatures are increased in response to clearcuts that have removed large quantities of vegetation. Elevated water temperatures on Mill Creek are also in part a response to the bedrock channel bottom the creek flows over. Brown (1970c) stated that bedrock bottoms are responsible for storing 15-20% of the thermal energy absorbed by a stream. The bedrock later releases the energy to the water resulting in the elevation of water temperature.

Suspended Sediment

The relationship between suspended sediment concentration and land use is a bit more obscure. Analysis of the data for the entire wet season shows no correlation between suspended sediment and land use or even discharge. Next, the data set was split into a fall and winter series on the premise that

seasonal sediment availability influences the relationship between discharge and suspended sediment concentration. A correlation between suspended sediment, land use and discharge was found with the fall series but not with the winter series. This stands to reason if one expects the quantity of suspended sediment available to the stream environment to decrease from a fall high to a winter low regardless of stream discharge.

Looking at adjusted R^2 values, the best prediction of suspended sediment within the fall series is by the model containing the independent variables of Q station and % forest. The next best model contains the independent variable of Q station alone. The standard error for the beta values in the Q station and % forest model is marginally acceptable or marginally unacceptable, and thus the model does not prove the the null hypothesis true or false. The relationship between % forest and suspended sediment is positive, thus showing that as the percent of forest land use increases so does the concentration of suspended sediment. This is counter-intuitive unless (a) there is some process unaccounted for generating sediment within the forested land, or (b) a spurious correlation has been generated.

The seasonal relationship between suspended sediment and discharge, within the Mohawk drainage basin, points to sediment availability as the limiting factor. A study by Rothacher, Dyrness, and Fredriksen (1967), revealed similar

findings, in that higher concentrations of suspended sediment were being transported during the fall than under similar discharge conditions during the winter.

Limitations and Suggestions

The predominant limitation to the water temperature and suspended sediment analyses is that both studies are based on data from one season. Several more years of data would help to define more clearly their relationship to land use, especially for the suspended sediment analysis. Furthermore, within the suspended sediment study a more complete coverage of storm events with water samples taken throughout the rising and falling limbs of storm discharge would help to illuminate the relationship between suspended sediment and discharge. Error may also be introduced into the analysis by the use of estimated values of station discharge. Land uses other than forest may indeed influence suspended sediment. The null hypothesis that land use is not influencing suspended sediment within the basin has not been disproved by the observations and analysis I have been able to make. Understanding of the large scale phenomena of the effects of various land uses on stream characteristics requires a great density of observational sampling in space and in time.

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APPENDIX A

TEMPERATURE DATA

Table 20

Water Temperature Data

LOCATION	DATE	TIME	STD TEMP F	PRES TEMP F	MAX TEMP F	MIN TEMP F
X1	8/2/86	7:30	69			
X2	8/1/86	11:45	64	64		
X3	8/2/86	9:06	61	61		
X4	8/1/86	13:00	58	58		
X5	8/1/86	14:25	62	62		
X6	8/2/86	10:00	62	62		
X1	8/8/86	13:00	75			
X2	8/8/86	9:30	--	68	74	62
X3	8/8/86	13:25	68	69	73	58
X4	8/8/86	14:05	63	63	64	55
X5	8/8/86	14:30	66	66	68	56
X6	8/8/86	15:00	71	70	72	58
X1	8/15/86	10:20	76			
X2	8/15/86	10:45	72	68	76	66
X3	8/15/86	11:10	69	63	70	61
X4	8/15/86	13:00	64	61	65	57
X5	8/15/86	13:30	68	63	68	57
X6	8/15/86	13:55	71	66	73	61
X1	8/22/86	10:00	70			
X2	8/22/86	10:30	66	65	73	63
X3	8/22/86	11:10	62	60	66	58
X4	8/22/86	11:35	57	56	63	53
X5	8/22/86	12:30	61	60	67	55
X6	8/22/86	10:50	62	60	75	58
LOCATION	DATE	TIME	STD TEMP F	PRES TEMP F	MAX TEMP F	MIN TEMP F
X1	8/28/86	8:45	71			
X2	8/28/86	9:15	68	66	72	62
X3	8/28/86	9:40	64	63	68	58
X4	8/28/86	100:00	60	60	62	54
X5	8/28/86	10:30	61	61	66	55
X6	8/28/86	10:50	64	63	68	57
X1	9/2/86	10:50	66			
X2	9/2/86	11:10	63	62	70	62
X3	9/2/86	11:30	58	60	65	57
X4	9/2/86	11:45	54	56	61	54
X5	9/2/86	12:10	59	57	66	56
X6	9/2/86	12:30	60	62	66	57
X1	9/22/86	11:30	59			
X2	9/22/86	12:00	57	56	72	53
X3	9/22/86	12:20	55	53	65	49
X4	9/22/86	12:40	51	50	61	47
X5	9/22/86	13:00	52	51	66	47
X6	9/22/86	13:25	56	54	67	49

Table 20 (Continued)

LOCATION	MILES	STAGE (ft)	STD TEMP C	PRES TEMP C	MAX TEMP C	MIN TEMP C
X1	0	0.92	20.56			
X2	5.75		17.78	17.78		
X3	11.75		16.11	16.11		
X4			14.44	14.44		
X5	17.35		16.67	16.67		
X6			16.67	16.67		
X1	0	0.87	23.89		24.50	
X2	5.75			20.00	23.33	16.67
X3	11.75		20.00	20.56	22.78	14.44
X4			17.22	17.22	17.78	12.78
X5	17.35		18.89	18.89	20.00	13.33
X6			21.67	21.11	22.22	14.44
X1	0	0.8	24.44		25.20	
X2	5.75		22.22	20.00	24.44	18.89
X3	11.75	(different	20.56	17.22	21.11	16.11
X4		std. thermom	17.78	16.11	18.33	13.89
X5	17.35	used)	20.00	17.22	20.00	13.89
X6			21.67	18.89	22.78	16.11
X1	0	0.78	21.11		24.80	
X2	5.75		18.89	18.33	22.78	17.22
X3	11.75		16.67	15.56	18.89	14.44
X4			13.89	13.33	17.22	11.67
X5	17.35		16.11	15.56	19.44	12.78
X6			16.67	15.56	23.89	14.44
LOCATION	MILES	STAGE (ft)	STD TEMP C	PRES TEMP C	MAX TEMP C	MIN TEMP C
X1	0	0.76	21.67		23.50	
X2	5.75		20.00	18.89	22.22	16.67
X3	11.75		17.78	17.22	20.00	14.44
X4			15.56	15.56	16.67	12.22
X5	17.35		16.11	16.11	18.89	12.78
X6			17.78	17.22	20.00	13.89
X1	0	0.78	18.89		22.30	
X2	5.75		17.22	16.67	21.11	16.67
X3	11.75	(different	14.44	15.56	18.33	13.89
X4		std. thermom	12.22	13.33	16.11	12.22
X5	17.35	used)	15.00	13.89	18.89	13.33
X6			15.56	16.67	18.89	13.89
X1	0	1.02	15.00		22.70	
X2	5.75		13.89	13.33	22.22	11.67
X3	11.75		12.78	11.67	18.33	9.44
X4			10.56	10.00	16.11	8.33
X5	17.35		11.11	10.56	18.89	8.33
X6			13.33	12.22	19.44	9.44

Table 21

Adjusted Water Temperature Data

LOCATION	DATE	TIME	PRES TEMP F	MAX TEMP F	MIN TEMP F	STAGE FT
X1	8/2/86	7:30	69			0.92
X2	8/1/86	11:45	64			
X3	8/2/86	9:06	61			
X4	8/1/86	13:00	58			
X5	8/1/86	14:25	62			
X6	8/2/86	10:00	62			
X1	8/8/86	13:00	75	76		0.87
X2	8/8/86	9:30	68	74	62	
X3	8/8/86	13:25	68	72	57	
X4	8/8/86	14:05	63	64	55	
X5	8/8/86	14:30	66	68	56	
X6	8/8/86	15:00	71	73	59	
X1	8/15/86	10:20	76	77		0.8
X2	8/15/86	10:45	68	76	66	
X3	8/15/86	11:10	63	70	61	(different
X4	8/15/86	13:00	61	65	57	std. thermom
X5	8/15/86	13:30	63	68	57	used)
X6	8/15/86	13:55	66	73	61	
X1	8/22/86	10:00	70	77		0.78
X2	8/22/86	10:30	66	74	64	
X3	8/22/86	11:10	62	68	60	
X4	8/22/86	11:35	57	64	54	
X5	8/22/86	12:30	61	68	56	
X6	8/22/86	10:50	62	77	60	
LOCATION	DATE	TIME	PRES TEMP F	MAX TEMP F	MIN TEMP F	STAGE FT
X1	8/28/86	8:45	71	74		0.76
X2	8/28/86	9:15	68	74	64	
X3	8/28/86	9:40	64	69	59	
X4	8/28/86	100:00	60	62	54	
X5	8/28/86	10:30	61	66	55	
X6	8/28/86	10:50	64	69	58	
X1	9/2/86	10:50	66	72		0.78
X2	9/2/86	11:10	63	71	63	
X3	9/2/86	11:30	58	63	55	(different
X4	9/2/86	11:45	54	59	52	std. thermom
X5	9/2/86	12:10	59	68	58	used)
X6	9/2/86	12:30	60	64	55	
X1	9/22/86	11:30	59	73		1.02
X2	9/22/86	12:00	57	73	54	
X3	9/22/86	12:20	55	67	51	
X4	9/22/86	12:40	51	62	48	
X5	9/22/86	13:00	52	67	48	
X6	9/22/86	13:25	56	69	51	

Table 21 (Continued)

LOCATION	DATE	PRES TEMP C	MAX TEMP C	MIN TEMP C	MILES	MAX TEMP C
X1	8/2/86	21			0	
X2	8/1/86	18			5.75	includes
X3	8/2/86	16			11.75	thermograph
X4	8/1/86	14				temps. (X1)
X5	8/1/86	17			17.35	
X6	8/2/86	17				
X1	8/8/86	24			0	25
X2	8/8/86	20	23	17	5.75	23
X3	8/8/86	20	22	14	11.75	23
X4	8/8/86	17	18	13		18
X5	8/8/86	19	20	13	17.35	20
X6	8/8/86	22	23	15		22
X1	8/15/86	24			0	25
X2	8/15/86	20	24	19	5.75	24
X3	8/15/86	17	21	16	11.75	21
X4	8/15/86	16	18	14		18
X5	8/15/86	17	20	14	17.35	20
X6	8/15/86	19	23	16		23
X1	8/22/86	21			0	25
X2	8/22/86	19	23	18	5.75	23
X3	8/22/86	17	20	16	11.75	19
X4	8/22/86	14	18	12		17
X5	8/22/86	16	20	13	17.35	19
X6	8/22/86	17	25	16		24
LOCATION	DATE	PRES TEMP C	MAX TEMP C	MIN TEMP C	MILES	MAX TEMP C
X1	8/28/86	22			0	24
X2	8/28/86	20	23	18	5.75	22
X3	8/28/86	18	21	15	11.75	14
X4	8/28/86	16	17	12		17
X5	8/28/86	16	19	13	17.35	19
X6	8/28/86	18	21	14		20
X1	9/2/86	19			0	22
X2	9/2/86	17	22	17	5.75	21
X3	9/2/86	14	17	13	11.75	18
X4	9/2/86	12	15	11		16
X5	9/2/86	15	20	14	17.35	19
X6	9/2/86	16	18	13		19
X1	9/22/86	15			0	23
X2	9/22/86	14	23	12	5.75	22
X3	9/22/86	13	19	11	11.75	18
X4	9/22/86	11	17	9		16
X5	9/22/86	11	19	9	17.35	19
X6	9/22/86	13	21	11		19

Table 22

Basin Characteristics for Each Station

	DRAINAGE	MAIN	DRAINAGE	SLOPE
	AREA	CHANNEL	DENSITY	
	(mi. sq.)	(miles)	(mi./mi. sq.)	(ft./mi.)
STATION				
1	178.46	28.8	4.9	0.02
2	146.47	22.8	5.1	0.025
3	78.5	16.6	4.9	0.033
4	13.51	4	5.8	0.037
5	34.45	10.6	4.8	0.049
6	32.2	10.8	6	0.036

Table 23

Percent Land Use Above Each Station

STATION	TOTAL AREA	% FOREST	% CUT-OVER	% NON-FOREST
X1	100.00	86.60	6.82	6.58
X2	100.00	87.22	7.78	5.00
X3	100.00	91.55	6.31	2.11
X4	100.00	93.86	6.07	0.00
X5	100.00	93.35	6.65	0.00
X6	100.00	81.37	17.33	1.33

Table 24

Data Entered in Statistical Analysis

	%CUT	% NON-FOREST	%FOREST	STATION	* CELSIUS	DRAINAGE AREA	MAIN CHANNEL LENGTH
1	6.65	0	93.35	5	20.0	89.22	17.06
2	6.65	0	93.35	5	20.0	89.22	17.06
3	6.65	0	93.35	5	20.0	89.22	17.06
4	6.65	0	93.35	5	18.9	89.22	17.06
5	6.65	0	93.35	5	20.0	89.22	17.06
6	6.65	0	93.35	5	19.4	89.22	17.06
7	6.07	0	93.86	4	17.8	34.99	6.44
8	6.07	0	93.86	4	18.3	34.99	6.44
9	6.07	0	93.86	4	17.8	34.99	6.44
10	6.07	0	93.86	4	16.7	34.99	6.44
11	6.07	0	93.86	4	15.0	34.99	6.44
12	6.07	0	93.86	4	16.7	34.99	6.44
13	6.31	2.11	91.55	3	22.2	203.32	26.71
14	6.31	2.11	91.55	3	21.1	203.32	26.71
15	6.31	2.11	91.55	3	20.0	203.32	26.71
16	6.31	2.11	91.55	3	20.6	203.32	26.71
17	6.31	2.11	91.55	3	17.2	203.32	26.71
18	6.31	2.11	91.55	3	19.4	203.32	26.71
19	17.33	1.33	81.37	6	22.8	83.40	17.38
20	17.33	1.33	81.37	6	22.8	83.40	17.38
21	17.33	1.33	81.37	6	25.0	83.40	17.38
22	17.33	1.33	81.37	6	20.6	83.40	17.38
23	17.33	1.33	81.37	6	17.8	83.40	17.38
24	17.33	1.33	81.37	6	20.6	83.40	17.38
25	7.78	5.00	87.22	2	23.3	379.36	36.69
26	7.78	5.00	87.22	2	24.4	379.36	36.69
27	7.78	5.00	87.22	2	23.3	379.36	36.69
28	7.78	5.00	87.22	2	23.3	379.36	36.69
29	7.78	5.00	87.22	2	21.7	379.36	36.69
30	7.78	5.00	87.22	2	22.8	379.36	36.69
31	6.82	6.58	86.60	1	24.4	462.21	46.43
32	6.82	6.58	86.60	1	25.0	462.21	46.34
33	6.82	6.58	86.60	1	25.0	462.21	46.34
34	6.82	6.58	86.60	1	23.3	462.21	46.34
35	6.82	6.58	86.60	1	22.2	462.21	46.34
36	6.82	6.58	86.60	1	22.8	462.21	46.34

25% COTTON FIBER

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U.S.A.

APPENDIX B

SUSPENDED SEDIMENT DATA

Transmitted

Table 25

Integrated and Grab Sampling Data

10/10/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
	14:20	X1 GRAB	3.4	11	32.2
	12:40	X2 GRAB	2.1	7	32.2
	13:00	X3 GRAB	2.8	9	32.2
	13:15	X4 GRAB	2.2	4	32.2
	13:40	X5 GRAB	2.1	4	32.2
	13:55	X6 GRAB	3.5	4	32.2
10/17/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
1.02	10:30	X1 INT.	1.8	14	30.5
		X1 GRAB	16	34	30.5
	12:00	X2 INT	2.6	14	30.5
		X2 GRAB	7.8	24	30.5
	12:45	X3 GRAB	4.9	21	31.3
	13:00	X4 GRAB	2.1	9	32.2
	15:00	X5 GRAB	2.2	10	32.2
		X5 INT	0.7	7	32.2
		X6 GRAB	2.3	25	32.2
10/30/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
1.54	13:00	X1 GRAB	5.4	12	94.8
	13:30	X2 GRAB	8.8	16	96.8
	14:30	X3 GRAB	13	14	100.9
	14:40	X3 INT	11	8	100.9
	15:45	X4 GRAB	6.4	14	105.1
	16:05	X5 GRAB	7.2	13	107.3
	16:35	X6 GRAB	5.6	6	107.3
	16:45	X6 INT	4.02	4	107.3
10/31/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
2.28	10:35	X1 GRAB	19	33	259.1
	10:50	X2 GRAB	12	20	261.7
	11:00	X3 GRAB	9.8	9	261.7
	11:10	X4 GRAB	6.4	10	261.7
	11:30	X5 GRAB	6	9	264.3
	13:10	X5 INT	3.9	7	264.3
	13:30	X6 GRAB	8.4	4	264.3
11/7/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
1.54	10:30	X1 GRAB	21	23	94.8
	10:50	X2 GRAB	4.5	11	100.9
	11:10	X3 GRAB	14	22	103
	12:00	X3 INT	17	28	111.7
	12:50	X4 GRAB	3.5	5	124
	13:10	X5 GRAB	8.3	16	128.2
	13:25	X6 GRAB	8.2	12	132.5
	13:35	X6 INT	6.1	8	136.9

Table 25 (Continued)

11/14/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
1.98	11:15				
	11:50	X1 GRAB	6.3	6	193.2
	12:00	X1 INT	6.5	9	193.2
11/21/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
7.2	10:45	X1 GRAB	27	67	1828
	11:00	X2 GRAB	19	47	1820
	11:15	X3 GRAB	16	36	1816
	11:25	X4 GRAB	13	23	1811
	11:45	X5 GRAB	12	21	1794
	12:05	X6 GRAB	17	28	1773
1.21	13:00	X4 ISCO	15	18	1740
12/5/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	11:20	X1	17	40	600.2
	11:35	X2	12	26	600.2
	11:50	X3	6.1	14	600.2
	12:05	X5	6.6	16	600.2
	12:30	X6	12	24	589.9
12/12/86	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	10:25	X1 GRAB	13	24	407.4
	10:35	X2 GRAB	7.3	10	387.2
	10:50	X3 GRAB	4.1	4	387.2
	11:05	X4 GRAB	4.2	4	387.2
	11:25	X5 GRAB	3	3	387.2
	11:40	X6 GRAB	5.1	6	387.2
1/24/87	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	15:10	X1 INT	14	24	772
	15:15	X1 GRAB	13	29	777
	15:40	X2 GRAB	12	26	798
	15:50	X3 GRAB	15	25	805
	16:00	X4 GRAB	15	20	812
	16:15	X5 GRAB	10	16	818
	16:30	X6 GRAB	15	31	824
1/30/87	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	15:10	X1 GRAB	7.9	6	1140
	13:25	X2 INT	5.7	7	1160
	13:30	X2 GRAB	6.9	9	1160
	14:05	X3 GRAB	5.7	8	1150
	14:20	X4 GRAB	5.7	8	1150
	14:35	X5 GRAB	6.1	6	1148
	14:50	X6 GRAB	6.9	9	1143

Table 25 (Continued)

Table 25 (Continued)

3/13/87	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	10:08	X1 INT	12	8.7	906
	10:10	X1 GRAB	13	8.5	906
	10:30	X2 GRAB	10	7	906
	10:45	X5 GRAB	8.7	7.3	906
	10:55	X3 GRAB	8.6	3.2	906
	11:05	X4 GRAB	9.6	5.6	906
	13:00	X5 INT	5.4	4	906
	13:02	X5 GRAB	6.2	4	906
3/15/87	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	10:19	X1 INT	7.8	7	1200
	10:22	X1 GRAB	7.5	8	1200
	13:30	X2 INT	4.9	5.5	1160
	13:32	X2 GRAB	5.2	5.4	1160
	15:13	X6 GRAB	5.6	5.7	1150
	15:22	X3 GRAB	4.5	5.3	1150
	15:30	X4 GRAB	4.2	5.2	1150
	15:52	X5 GRAB	3.5	3.7	1150
3/20/87	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	10:54	X1 INT	5.3	3.9	785
	10:56	X1 GRAB	8.8	6	785
	11:15	X2 GRAB	5.3	4	785
	11:31	X3 GRAB	4.2	3	785
	11:43	X4 GRAB	5.4	3.2	782
	12:06	X5 GRAB	4	2.4	779
	14:22	X6 INT	4.2	3.3	777
	14:24	X6 GRAB	5.4	3.4	777
3/27/87	TIME	BOTTLE	TURBIDITY	SUSP. SED. (mg/l)	Q at X1
STAGE					
	10:24	X1 INT	4.5	3.7	534
	10:27	X1 GRAB	5.3	3.4	534
	10:48	X2 GRAB	4.5	3.2	534
	11:05	X6 GRAB	4.5	2.4	534
	11:18	X3 GRAB	4.1	2.2	534
	11:28	X4 GRAB	4.2	2.7	534
	11:45	X5 GRAB	2.9	1.6	534

Table 26

Velocity and Channel Dimensions for Integrated Sampling

LOCATION:	Mohawk R. X2	above bridge	PARTY: Schloss, Campbell		
DATE:		8/8/86	START TIME:	10:30	
METER TYPE:	AA		END TIME:	11:00	
BRIDGE ANGLE					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE
right bank					
66	65		0		
64	63	2			
62	60	3	0.7	0.15	0.315
58	56	4	0.9	0.15	0.54
54	52	4	0.95	0.15	0.57
50	48	4	1.2	0.2	0.96
46	44	4	1.4	0.25	1.4
42	40	4	1.7	0.2	1.36
38	36	4	1.85	0.3	2.22
34	32	4	1.9	0.35	2.66
30	28	4	1.9	0.25	1.9
26	24	4	1.8	0.3	2.16
22	20	4	1.7	0.25	1.7
18	16	4	1.6	0.35	2.24
14	12	4	1.4	0.3	1.68
10	8	4	1.35	0.25	1.35
6	4	4	1.7	0.15	1.02
2	1	3	2.3	0.15	1.035
			2.3	0.05	0
			2.3	0.05	0
			2	0	
			1.7	0	
		Left bank			

Table 26 (Continued)

LOCATION:	Mohawk X2		PARTY:	Mele, Campbell	
DATE:	10/17/86		START TIME:	11:30	
METER TYPE:	AA		END TIME:	12:00	
BRIDGE ANGLE					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE
0	2		0	0	
4	6	4	0.9	0.05	0.18
8	10	4	1.3	0.05	0.26
12	14	4	1.9	0.05	0.38
16	18	4	2.4	0.1	0.96
20	22	4	2	0.15	1.2
24	26	4	1.5	0.25	1.5
28	30	4	1.4	0.35	1.96
32	34	4	1.5	0.45	2.7
36	38	4	1.6	0.45	2.88
40	42	4	1.8	0.4	2.88
44	46	4	1.8	0.4	2.88
48	50	4	1.9	0.3	2.28
52	54	4	1.8	0.35	2.52
56	58	4	1.8	0.3	2.16
60	62	4	1.7	0.3	2.04
64	66	4	1.3	0.3	1.56
68	70	4	1.1	0.2	0.88
72	74	4	0.9	0.2	0.72
76	78	4	0.9	0.05	0.18
80	81	3	0.5	0	0
82					
				Discharge	30.12

Table 26 (Continued)

LOCATION:	Mohawk X5		PARTY:	Mele, Campbell	
DATE:	10/17/86		START TIME:	14:45	
METER TYPE:	AA		END TIME:	15:00	
BRIDGE ANGLE					
DISTANCE	Column edge	WIDTH (ft)	DEPTH	VELOCITY	DISCHARGE
0	0.5		right bank		
1	2	1.5	0.7	0.25	0.2625
3	4	2	1.3	0.9	2.34
5	6	2	1.3	0.15	0.39
7	8	2	1.2	0.55	1.32
9	10	2	0.9	0.5	0.9
11	12	2	0.8	0.9	1.44
13	14	2	0.7	1	1.4
15	16	2	1.3	0.9	2.34
17	18	2	0.9	0.7	1.26
19	20	2	0.7	0.85	1.19
21	22.5	2.5	0.7	0.75	1.3125
24					
				Discharge	14.155
LOCATION:	Mohawk X3		PARTY:	Mele, Campbell	
DATE:	10/30/86	START TIME:	14:50	END TIME:	15:25
METER TYPE:	AA				
BRIDGE ANGLE					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE
0	1.5	left bank	upstream		
3	4.5	3	0.7	0.4	0.84
6	7.5	3	0.8	1.15	2.76
9	10.5	3	0.8	0.7	1.68
12	13.5	3	1.1	0.9	2.97
15	16.5	3	1.4	1.2	5.04
18	19.5	3	1.3	1.1	4.29
21	22.5	3	1.7	1.1	5.61
24	25.5	3	1.8	0.9	4.86
27	28.5	3	1.9	1.05	5.985
30	31.5	3	1.8	0.85	4.59
33	34.5	3	2	1.1	6.6
36	37.5	3	1.9	1.25	7.125
39	40.5	3	1.5	1.1	4.95
42	43.5	3	1.7	1.1	5.61
45	46.5	3	1.2	0.8	2.88
48	49.5	3	0.6	0.7	1.26
51					
				Discharge	67.05

Table 26 (Continued)

LOCATION:	Mill Creek X6		PARTY:	Mele, Campbell	
DATE:	10/30/86	START TIME:	16:50	END TIME:	17:10
METER TYPE:	AA				
BRIDGE ANGLE					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE
2	3				
4	5	2	0.6	0.05	0.06
6	7	2	0.9	0.3	0.54
8	9	2	1	1.05	2.1
10	11	2	1	2.1	4.2
12	13	2	0.9	2.35	4.23
14	15	2	1	2.2	4.4
16	17	2	1.1	1.95	4.29
18	19	2	1	1.1	2.2
20	21	2	0.8	0.7	1.12
22	23	2	0.4	0.2	0.16
24	25	2	0.3	1.35	0.81
26	27	2	0.3	1.3	0.78
28	29	2	0.2	0	0
30	31	2	0	0	0
32	33	2	0.3	0.6	0.36
34	35	2	0	0	0
36					
				Discharge	25.25
LOCATION:	Mohawk X5		PARTY:	Campbell	
DATE:	10/31/86	START TIME:	11:55	END TIME:	13:00
METER TYPE:	AA				
BRIDGE ANGLE					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE
5	5.5	right bank			
6	6.5	1	0.1		
7	7.5	1	0.3		
8	10	2.5	0.2		
12	13	3	0.2		
14	15	2	0.3	0.95	0.57
16	17	2	0.7	1.35	1.89
18	19	2	2.4	1.3	6.24
20	21	2	1.8	0.2	0.72
22	23	2	1.9	0.5	1.9
24	25	2	1.6	0.7	2.24
26	27	2	1.4	0.9	2.52
28	29	2	1.2	1.05	2.52
30	31	2	1.8	0.9	3.24
32	33	2	1.4	0.6	1.68
34	35	2	0.5	0.9	0.9
36	37	2	0.9	0.7	1.26
38	39	2	0.7	0.2	0.28
40					
				Discharge	25.96

Table 26 (Continued)

LOCATION:	Monawk X1	PARTY:	Campbell					
DATE:	1/24/87	START TIME:	14:10	END TIME:	14:54			
METER TYPE:	AA							
BRIDGE ANGLE:					GAGE X1:	772		
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
0	0 right upstrm							
5.5	7.25	7.25	1.9	0.6	8.265	71	90	90
9	10.5	5.25	2.8	1.1	10.01	70	98	95
12	13.5	3	3.1	7.7	71.61	70	101	97
15	16.5	3	3.5	4.9	51.45	70	105	99
18	19.5	3	4	0	0	70	110	102
21	22.5	3	4.5	3.6	48.6	70	115	105
24	25.5	3	4.8	4.6	66.24	69	117	106
27	28.5	3	4.9	4.4	64.68	69	118	106
30	31.5	3	4.9	4.6	67.62	69	118	106
33	34.5	3	4.7	4.6	64.86	69	116	105
36	37.5	3	4.2	5.1	64.26	69	111	102
39	40.5	3	4	4.8	57.6	69	109	101
42	43.5	3	3.7	5.2	57.72	69	106	99
45	46.5	3	3.3	4.1	40.59	69	102	97
48	49.5	3	3.3	4.3	42.57	67	100	95
51	52.5	3	3.1	2.5	23.25	68	99	95
54	55.5	3	2.6	3.3	25.74	68	94	92
57	58.5		1.6	2.1	0	67	83	85
DISCHARGE =					765			
LOCATION:	Monawk X2	PARTY:	Campbell					
DATE:	1/30/87	START TIME:	11:00	END TIME:	13:12			
METER TYPE:	AA							
BRIDGE ANGLE:					GAGE X1:	1160		
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(2.6, 8) FT.				
0	0 right upstrm							
6	8	8	2.9	0.2	4.64	84	113	109
10	12	4	3.9	0.3	4.68	84	123	115
14	16	4	6.2	0.3	7.44	86	148	131
18	18	4	8.1	0.45	14.58	85	166	109
18	20	0	8.1	0	0	85	166	158
22	22	4	8.7	1.15	40.02	86	173	111
22	24	0	8.7	0	0	86	173	164
26	26	4	8.3	1.25	41.5	86	169	111
26	28	0	8.3	0	0	86	169	160
30	30	4	7.7	1.95	60.06	86	163	109
30	32	0	7.7	0	0	86	163	156
34	34	4	7.1	2.5	71	86	157	108
34	36	0	7.1	0	0	86	157	151
38	38	4	6.8	2.55	69.36	86	154	108
38	40	0	6.8	0	0	86	154	148
42	42	4	6.5	3.15	81.9	86	151	107
42	44	0	6.5	0	0	86	151	146
46	46	4	6.2	3.45	85.56	86	148	106
46	48	0	6.2	0	0	86	148	144
50	50	4	6	3.7	88.8	86	146	106
50	52	0	6	0	0	86	146	142
54	54	4	5.9	3.6	84.96	86	145	106
54	56	0	5.9	0	0	86	145	141
58	58	4	5.7	3.4	77.52	86	143	105
58	60	0	5.7	0	0	86	143	140
62	62	4	5.8	3.15	73.08	86	144	106
62	64	0	5.8	0	0	86	144	140
66	66	4	6.1	3.1	75.64	86	147	106
66	68	0	6.1	0	0	86	147	143
70	70	6	6.7	3.15	126.63	86	153	107
70	74	0	6.7	0	0	86	153	148
78	78	6	5.2	1.95	60.84	86	138	104
78	80	0	5.2	0	0	86	138	136
82	82	4	5.5	1.8	39.6	86	141	105
82	84	0	5.5	0	0	86	141	138
86	88	4	4.8	1.2	23.04	86	134	123
90	92.5	4.5	3.1	0.9	12.555	86	117	113
95	47.5		0					
DISCHARGE =					1143			

Table 26 (Continued)

LOCATION:	Mohawk X3	PARTY:	Campbell					
DATE:	2/6/87	START TIME:	11:40	END TIME:	12:50			
METER TYPE:	AA							
BRIDGE ANGLE				GAGE X1:	1090			
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(2, 6, 8) FT				
0	0	right upstrm						
3	4.5	4.5	1.6	0.1	0.72	15	31	33
6	7.5	3	2.6	0.8	6.24	15	41	39
9	10.5	3	3.3	1	9.9	15	48	43
12	13.5	3	3.6	1.6	17.28	15	51	45
15	16.5	3	4.2	2.2	27.72	15	57	48
18	19.5	3	4.1	3.4	41.82	15	56	48
21	21	3	4.9	4.5	66.15	15	64	33
21	22.5	0	4.9	0	0	15	64	62
24	24	3	5	3.9	58.5	15	65	33
24	25.5	0	5	0	0	15	65	63
27	27	3	5	3.9	58.5	15	65	33
27	28.5	0	5	0	0	15	65	63
30	30	3	5.2	3.8	59.28	15	67	33
30	31.5	0	5.2	0	0	15	67	65
33	33	3	4.7	2.9	40.89	15	62	32
33	34.5	0	4.7	0	0	15	62	61
36	36	3	4.6	2.9	40.02	15	61	32
36	37.5	0	4.6	0	0	15	61	60
39	40.5	3	4	2.6	31.2	15	55	47
42	43.5	3	3.6	1.5	16.2	15	51	45
45	46.5	3	3.7	0.7	7.77	15	52	45
48	49.5	3	2.5	0.5	3.75	15	40	38
51	52.5	3	2.3	0.5	3.45	15	38	37
54	56.5	4				15	32	
59				DISCHARGE =	489			
LOCATION:	Mohawk X5	PARTY:	Campbell					
DATE:	2/13/87	START TIME:	12:10	END TIME:	14:05			
METER TYPE:	AA							
BRIDGE ANGLE				GAGE X1:	731			
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(6) FT				
0	0	right upstrm						
3	4.5	4.5	0.06	1	0.27			
6	8	3.5	0.07	1.6	0.392			
10	11	3	2.1	1.2	7.56	82	103	101
12	13	2	2.9	2.6	15.08	79	108	102
14	15	2	3	2.5	15	80	110	104
16	17	2	2	3.7	14.8	80	100	98
18	19	2	2.1	4.1	17.22	79	100	98
20	21	2	2.4	3.3	15.84	76	100	96
22	23	2	2.4	3.4	16.32	76	100	96
24	25	2	1.8	3.5	12.6	76	94	93
26	27	2	1.7	2.6	8.84	74	91	90
28	29	2	1.8	1.4	5.04	73	91	90
30	31	2	1.6	1.1	3.52	72	88	88
32	32	1	0.9			71	80	
				DISCHARGE =	132			
LOCATION:	Mohawk X6	PARTY:	Campbell					
DATE:	2/14/87	START TIME:	11:30	END TIME:	12:20			
METER TYPE:	AA							
BRIDGE ANGLE				GAGE X1:	890			
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(6) FT				
0	0	right upstrm						
21	22.5	22.5	1.2	3.7	99.9	46	58	59
24	27	4.5	1.2	2.8	15.12	44	56	57
30	31.5	4.5	1.3	3.5	20.475	42	55	56
33	36.5	5	1.4	4.2	29.4	43	57	57
40	41.5	5	1.1	3.8	20.9	36	47	49
43	44.5	3	1.8	4.4	23.76	36	54	53
46	47.5	3	1.5	4.4	19.8	38	53	53
49	50.5	3	1.3	3.5	13.65	39	52	53
52	53.5	3	1.8	3.3	17.82	37	55	54
55	56.5	3	1.5	1.2	5.4	37	52	52
58	60	3.5	1.3	0.6	2.73	36	49	50
60				DISCHARGE =	269			

Table 26 (Continued)

LOCATION:	Mohawk XI	PARTY:	Campbell					
DATE:	2/14/87	START TIME:	14:35	END TIME:	16:12			
METER TYPE:	AA							
BRIDGE ANGLE			GAGE XI:					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(2.5, 8) FT				
0	0	right upstrm						
5	6.5	6.5	2.7	0.6	10.5	66	93	88
8	9.5	3	3.5	0.7	7.4	66	101	93
11	12.5	3	3.5	1.1	11.6	68	103	95
14	14	3	4	1.4	16.8	68	108	82
14	15.5	0	4	0	0.0	68	108	106
17	17	3	4.4	2	26.4	68	112	83
17	18.5	0	4.4	0	0.0	68	112	109
20	20	3	5	2.6	39.0	67	117	83
20	21.5	0	5	0	0.0	67	117	113
23	23	3	5.3	3.4	54.1	67	120	84
23	24.5	0	5.3	0	0.0	67	120	115
26	26	3	5.5	3.9	64.4	69	124	86
26	27.5	0	5.5	0	0.0	69	124	119
29	29	3	5.4	4.3	69.7	69	123	84
29	30.5	0	5.4	0	0.0	67	123	118
32	32	3	5.7	5.3	90.6	67	124	84
32	33.5	0	5.7	0	0.0	67	124	119
35	35	3	5.1	6.1	93.3	67	118	83
35	36.5	0	5.1	0	0.0	67	118	114
38	38	3	4.9	5.3	77.9	67	116	83
38	39.5	0	4.9	0	0.0	67	116	112
41	41	3	4.4	4.8	63.4	67	111	82
41	42.5	0	4.4	0	0.0	67	111	108
44	45.5	3	4.3	4.5	58.1	67	110	82
44	47	0	4.3	0	0.0	67	110	107
47	48.5	3	4	4.5	54.0	67	107	81
47	51.5	0	4	0	0.0	67	107	105
50	54.5	3	3.8	4.4	50.2	67	105	96
53	57.5	3	3.6	4.1	44.3	68	104	96
56	60.5	3	3	3.5	31.5	67	97	91
59	64	3.5	3	2.1	22.1	66	85	83
62	66	2	1.2	1.4	3.4	66	78	79
66								
				DISCHARGE =	888			

Table 26 (Continued)

LOCATION:	Mohawk X2	PARTY:	Campbell					
DATE:	3/6/87	START TIME:	10:40	END TIME:	12:45			
METER TYPE:	AA							
BRIDGE ANGLE:		GAGE X1:	443					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(2.6 x 8) FT				
0	0	0	0	0	0	0	0	0
4	6	6	1.6	0	0.0	14	30	30
8	10	4	3.8	0.1	1.5	14	52	43
12	12	4	6.2	0.3	7.4	15	77	33
12	14	0	6.2	0	0.0	15	77	71
16	16	4	6.5	0.4	10.4	15	80	34
16	18	0	6.5	0	0.0	15	80	73
20	20	4	6.6	0.7	18.5	15	81	34
20	22	0	6.6	0	0.0	15	81	74
24	24	4	5.9	1.4	33.0	15	74	33
24	26	0	5.9	0	0.0	15	74	68
28	28	4	5.3	1.6	33.9	16	69	33
28	30	0	5.3	0	0.0	16	69	64
32	32	4	4.9	1.9	37.2	16	65	32
32	34	0	4.9	0	0.0	16	65	61
36	36	4	4.5	1.9	34.2	16	61	31
36	38	0	4.5	0	0.0	16	61	58
40	40	4	4.5	2.1	37.8	16	61	31
40	42	0	4.5	0	0.0	16	61	58
44	44	4	4.1	2.1	34.4	16	57	30
44	46	0	4.1	0	0.0	16	57	55
48	48	4	4	2	32.0	16	56	30
48	50	0	4	0	0.0	16	56	54
52	52	4	3.8	2.1	31.9	16	54	30
52	54	0	3.8	0	0.0	16	54	52
56	56	4	3.7	2.1	31.1	17	54	30
56	58	0	3.7	0	0.0	17	54	53
60	60	4	3.9	2	31.2	17	56	31
60	62	0	3.9	0	0.0	17	56	54
64	64	4	4.4	1.9	33.4	17	61	32
64	66	0	4.4	0	0.0	17	61	58
68	68	4	4.7	1.5	28.2	17	64	29
68	70	0	4.7	0	0.0	17	64	61
72	72	4	3.3	1.4	18.5	17	50	30
72	74	0	3.3	0	0.0	17	50	49
76	76	4	3.4	1.2	16.3	17	51	30
76	78	0	3.4	0	0.0	17	51	50
80	82	4	2.7	1	10.8	17	44	39
84	90	8	2.7	1.8	38.9	17	43	39
90					521			
LOCATION:	Mohawk X3	PARTY:	Campbell					
DATE:	3/7/87	START TIME:	11:45	END TIME:	13:19			
METER TYPE:	AA							
BRIDGE ANGLE:		GAGE X1:	412					
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(6) FT				
0	0	0	0	0	0	0	0	0
3	4.25	4.25	1.5	0	0.0	25	40	40
5.5	6.75	2.5	2.1	0.2	1.1	26	47	45
8	9.25	2.5	2.5	0.3	1.9	27	52	48
10.5	11.75	2.5	3.1	0.6	4.7	27	58	52
13	14.25	2.5	3.2	0.7	5.6	27	59	52
15.5	16.75	2.5	3	0.9	6.8	27	57	51
18	19.25	2.5	3.5	2.4	21.0	27	62	54
20.5	21.75	2.5	3.8	2.2	20.9	27	65	56
23	24.25	2.5	4.1	2.2	22.6	28	69	59
25.5	26.75	2.5	3.9	2.7	26.3	29	68	58
28	29.25	2.5	4	2.6	26.0	28	68	58
30.5	31.75	2.5	3.6	1.2	10.8	29	65	57
33	34.25	2.5	3.2	1.2	9.6	29	61	54
35.5	36.75	2.5	2.9	1.6	11.6	29	58	54
38	39.25	2.5	2.8	1.2	8.4	29	57	52
40.5	41.75	2.5	2.4	0.5	3.0	29	53	49
43	44.25	2.5	2.3	0.2	1.2	30	53	50
45.5	54	9.75	1.3	0.2	2.5	30	43	44
54					184			

Table 26 (Continued)

LOCATION:	Mohawk X5	PARTY:	Campbell					
DATE:	3/13/87	START TIME:	12:20	END TIME:				
METER TYPE:	AA							
BRIDGE ANGLE				GAGE X1:	906			
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(.6) FT				
0	0	right upstrm						
3	4.5	4.5	0.07	1.2	0.4			
6	7	2.5	0.07	1.3	0.2			
8	9	2	0.08	1.8	0.3			
10	11	2	1.4	2.5	7.0	79	93	93
12	13	2	2.5	2.9	14.5	78	103	99
14	15	2	2.6	4.2	21.8	77	103	99
16	17.5	2.5	2.7	3.7	25.0	77	104	99
19	20	2.5	2.3	3.5	20.1	77	100	97
21	22	2	2	4.4	17.6	75	95	93
23	24	2	1.9	3.8	14.4	76	95	93
25	26	2	1.6	4.1	13.1	73	89	89
27	29	3	2.3	2.4	16.6	72	95	92
31	37	8	1.3	1.1	11.4	72	85	86
37								
					151			
LOCATION:	Mohawk X2	PARTY:	Campbell					
DATE:	3/15/87	START TIME:	11:20	END TIME:	13:22			
METER TYPE:	AA							
BRIDGE ANGLE				GAGE X1:	1160			
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
				(.2, .6, .8) FT				
0	0	right upstrm						
7	9	9	2.5	0.2	4.5	97	122	118
11	11	4	4.5	0.3	5.4	96	141	111
11	13	0	4.5	0	0	96	141	138
15	15	4	6.9	0.45	12.42	96	165	116
15	17	0	6.9	0	0	96	165	157
19	19	4	8.1	0.55	17.82	96	177	118
19	21	0	8.1	0	0	96	177	167
23	23	4	8.3	1.15	38.18	96	179	119
23	25	0	8.3	0	0	96	179	168
27	27	4	7.8	1.45	45.24	97	175	119
27	29	0	7.8	0	0	97	175	166
31	31	4	7.4	2.1	62.16	97	171	118
31	33	0	7.4	0	0	97	171	162
35	35	4	6.8	2.55	69.36	97	165	117
35	37	0	6.8	0	0	97	165	157
39	39	4	6.6	3.1	81.84	97	163	116
39	41	0	6.6	0	0	97	163	156
43	43	4	6.2	3.3	81.84	97	159	115
43	45	0	6.2	0	0	97	159	153
47	47	4	6	3.5	84	97	157	115
47	49	0	6	0	0	97	157	151
51	51	4	5.8	3.4	78.88	98	156	116
51	53	0	5.8	0	0	98	156	150
55	55	4	5.6	3.5	78.4	98	154	115
55	57	0	5.6	0	0	98	154	149
59	59	4	5.5	3.3	72.6	98	153	115
59	61	0	5.5	0	0	98	153	148
63	63	4	5.6	3.1	69.44	98	154	115
63	65	0	5.6	0	0	98	154	149
67	67	4	6.1	2.9	70.76	98	159	116
67	69	0	6.1	0	0	98	159	153
71	71	5.5	6.5	3	107.25	98	163	117
71	74.5	0	6.5	0	0	98	163	156
78	78	5.5	5.3	2	58.3	98	151	115
78	80	0	5.3	0	0	98	151	146
82	82	4	5.1	1.9	38.76	98	149	114
82	84	0	5.1	0	0	98	149	145
86	86	4	4.4	1.3	22.88	98	142	113
86	88	0	4.4	0	0	98	142	139
90	94	6	3	1	18	98	128	122
94								
				DISCHARGE =	1118			

Table 26 (Continued)

LOCATION:	Mohawk X6	PARTY:	Campbell					
DATE:	3/20/87	START TIME:	12:40	END TIME:	14:10			
METER TYPE:	AA							
BRIDGE ANGLE:				GAGE X1:	777			
DISTANCE	Column edge	WIDTH	DEPTH	VELOCITY	DISCHARGE	SURFACE	BOTTOM	CUP DEPTH
			(.6) FT.					
0	0 right upstrm							
3	4.5	4.5	0.075	0	0.0			
6	7.5	3	0.04	0.5	0.1			
9	10.5	3	0.065	0.4	0.1			
12	13.5	3	0.065	1.1	0.2			
15	16.5	3	0.075	0.9	0.2			
18	19.5	3	0.09	3.5	0.9			
21	25.75	6.25	0.1	4.4	2.8			
30.5	32.25	6.5	1.1	3.3	23.6	43	54	56
34	38.5	6.25	1.3	4.4	35.8	42	55	56
43	44.5	6	1.2	4.4	31.7	39	51	52
46	47.5	3	1.5	4	18.0	39	54	54
49	50.5	3	1.4	3.2	13.4	39	53	53
52	53.5	3	1.5	3.1	14.0	39	54	54
55	56	2.5	1.5	0.9	3.4	37	52	52
57	61	5	1.2	1.8	10.8	37	49	50
61								
				DISCHARGE =	155			

Permanized

PILOVER BOND

25% COTTON FIBER

U.S.A.

	STATION	SEDIMENT	% FOREST	% CUT	% NON FOREST	DRAIN AREA	DRAIN DENSE	MAIN CHAN	SOIL 1	SOIL 2	SOIL 3	SOIL 4	SOIL 5	SOIL 6	QH1	Q t station
1	1	9.1	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	32.2	32
2	1	14.0	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	30.5	31
3	1	9.6	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	94.8	95
4	1	19.4	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	259.1	259
5	1	14.9	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	94.8	95
6	1	9.0	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	193.2	193
7	1	35.3	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	1828.0	1828
8	1	22.7	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	600.2	600
9	1	15.2	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	407.4	407
10	1	24.0	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	772.0	772
11	1	6.7	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	1140.0	1140
12	1	9.6	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	1090.0	1090
13	1	11.0	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	721.0	721
14	1	9.6	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	872.0	872
15	1	15.0	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	451.0	451
16	1	3.6	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	416.0	416
17	1	8.7	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	906.0	906
18	1	7.0	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	1200.0	1200
19	1	3.9	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	785.0	785
20	1	3.7	86.60	6.82	6.58	462.0	3.0	46.3	7.59	.69	.54	19.35	47.20	23.02	53.4	53
21	2	6.2	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	32.2	71
22	2	14.0	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	30.5	30
23	2	10.3	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	96.8	132
24	2	12.1	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	261.7	287
25	2	8.0	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	100.9	136
26	2	24.6	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	1820.0	1751
27	2	14.9	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	600.2	600
28	2	7.5	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	387.2	405
29	2	14.9	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	798.0	791
30	2	7.0	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	1160.0	1143
31	2	5.7	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	1090.0	1065
32	2	8.0	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	726.0	723
33	2	22.0	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	443.0	519
34	2	4.6	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	415.0	431

Table 27

Statistical Data Used in Suspended Sediment Analysis

	STATION	SEDIMENT	% FOREST	% CUT	% NON FOREST	DRAIN AREA	DRAIN DENSE	MAIN CHAN	SOIL 1	SOIL 2	SOIL 3	SOIL 4	SOIL 5	SOIL 6	QHI	Q t station
35	2	6.2	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	906.0	892
36	2	5.5	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	1160.0	1096
37	2	4.8	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	785.0	779
38	2	4.4	82.70	7.13	4.82	379.2	3.4	36.7	6.92	0	0	15.82	49.90	26.39	534.0	543
39	3	8.0	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	32.2	30
40	3	23.1	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	31.3	30
41	3	8.0	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	100.9	67
42	3	8.0	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	261.7	129
43	3	28.0	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	111.7	65
44	3	41.9	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	1816.0	799
45	3	14.3	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	600.2	275
46	3	1.7	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	387.2	184
47	3	28.1	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	805.0	364
48	3	6.7	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	1150.0	512
49	3	5.5	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	1090.0	490
50	3	6.7	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	728.0	330
51	3	11.8	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	890.0	400
52	3	11.8	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	446.0	209
53	3	2.7	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	412.0	412
54	3	.7	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	906.0	407
55	3	3.4	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	1150.0	512
56	3	.5	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	785.0	355
57	3	-.5	91.32	6.48	2.18	182.6	3.0	24.8	4.10	0	0	9.34	52.30	33.66	534.0	247
58	5	2.7	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	32.2	3
59	5	7.0	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	32.2	14
60	5	11.8	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	107.3	16
61	5	7.0	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	264.3	26
62	5	14.8	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	128.2	20
63	5	19.9	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	1794.0	306
64	5	14.8	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	600.2	101
65	5	1.7	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	387.2	64

Table 27 (Continued)

	STATION	SEDIMENT	% FOREST	% CUT	% NON FOREST	DRAIN AREA	DRAIN DENSE	MAIN CHAN	SOIL 1	SOIL 2	SOIL 3	SOIL 4	SOIL 5	SOIL 6	QHI	Q t station
66	5	14.8	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	818.0	138
67	5	4.7	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	1148.0	195
68	5	6.7	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	1090.0	185
69	5	16.0	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	731.0	132
70	5	8.8	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	875.0	148
71	5	8.8	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	447.0	75
72	5	1.9	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	410.0	68
73	5	4.0	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	906.0	151
74	5	2.4	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	1150.0	196
75	5	1.1	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	779.0	132
76	5	.3	93.35	6.65	0	89.2	3.0	17.1	.41	0	0	0	44.37	55.95	534.0	90
77	6	4.0	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	107.3	25
78	6	3.2	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	264.3	61
79	6	8.0	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	136.9	27
80	6	18.0	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	1773.0	469
81	6	15.5	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	589.9	149
82	6	4.5	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	387.2	94
83	6	9.8	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	824.0	213
84	6	6.3	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	1143.0	299
85	6	6.3	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	728.0	187
86	6	12.0	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	890.0	269
87	6	9.4	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	449.0	111
88	6	2.9	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	410.0	101
89	6	5.3	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	906.0	235
90	6	4.3	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	1150.0	301
91	6	3.3	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	777.0	155
92	6	2.2	81.37	17.33	1.33	83.4	3.7	17.4	2.95	0	0	18.52	52.91	27.33	534.0	134

Table 27 (Continued)

Table 28

Percent Land Use for Suspended Sediment Stations

STATION	TOTAL AREA	% FOREST	% CUT-OVER	% NON-FOREST
1	100	86.6	6.82	6.58
2	100	82.7	7.13	4.82
3	100	91.32	6.48	2.18
4	100	94.21	5.73	0
5	100	93.35	6.65	0
6	100	81.37	17.33	1.33

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Permanized
PLOVER BOND
25% COTTON FIBER
U.S.A.

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